# Electrochemical and Metallurgical Industry

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## CONTENTS.

## Niagara Falls Meeting of the American Electrochemical Society.

In its short career of seven years the American Electrochemical Society has held many highly successful meetings, but none more successful than the convention last month in Niagara Falls. The society was formed seven years ago at the right moment to become useful, and in its career the society has never missed the psychological moment when there was an opportunity to prove useful. A case in point was the symposium of papers on the electrometallurgy of iron and steel at the Niagara meeting. But the balance of the program was equally attractive. The result was a record-breaking attendance, not only at the convention in general, but in all the sessions devoted to the reading and discussion of papers. The esprit de corps which unites the congenial members of this society—though they be scientists or engineers, electrochemists or chemists or metallurgists or electrical engineers—was as dominant as ever, and the social functions were immensely enjoyed. Great credit is due to all Niagara Falls members who did so much for the success of the meeting, under the leadership of President Acheson.

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But any words of appreciation, however brief, would be wholly incomplete without special mention of "Section Q." It was amusing enough when a speaker at the banquet in making announcements for the convention to be held 25 years hence at Niagara Falls attributed various activities to the Sections A, B, C . . . finally coming down to Q as the section devoted to the utilization and absorption of alcoholic solutions. But this was a little bit hard on Section Q after its record of the night before. Whatever may have been its primordial history, surely at its session held after the official smoker it proved that it has a mission to fulfill. In vino veritas. Nobody has any right to appoint himself a pronouncer of truths about others in a "holier-than-thou" attitude. But nobody would dream of such an attitude in Section Q, and if truths are told in such a kindly spirit of fun and in such a clever way as Section Q did with its cartoons of members and its experimental lectures, even thin-skinned dignity should not feel hurt. Cartoons of men are like integrals between certain limits. They are true, but between the assumed limits, and any scholar of modern physics understands that. The different cartoons, experimental lectures, and other features of this extravaganza session were by no means artistically equivalent, but they were all inspired with the same frolicsome merriment. Section Q was born, not made. It is the natural outcome of the peculiar congenial atmosphere that comes with every meeting of the Electrochemical Society. It is a symptom of perfect health. It acts as a safety valve. It is irrepressible. This is the raison d'être of Section Q.

## The Symposium of Papers on the Electrometallurgy of Iron and Steel.

As expected, the symposium of papers on the use of the electric furnace in the iron and steel industry proved a great drawing card and turned out a great success. The whole of two long sessions during the first day of the convention was thereby taken up. The program was logically divided into two parts, firstly, the reduction of pig iron from ore, and secondly, the making and refining of steel in the electric furnace. Under average conditions, in this and most other countries, the use of the electric furnace for pig-iron reduction is mainly of theoretical interest. This was clearly indicated in the papers, as far as they recorded actual developments. In Norway, Canada, and California, where the intention is to use the electric furnace commercially for iron-ore reduction, there exist very special conditions, unfavorable to blast-furnace practice and favorable to electric-iron furnaces. The conditions in California were well sketched by Mr. Bennie, and the situation in Canada and Norway is in many respects similar. But the papers presented at the convention emphasized properly, with special stress, the furnace design. The problem in its general and economic aspects has been so often discussed that, as Dr. Haanel said, the one thing that remained to be done now was to design a proper furnace and run it continually for a proper length of time.

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This has been done and is being done in Sweden and in California, and it is interesting to compare the two furnace designs. They have much in common, a high shaft being superposed in both designs upon a crucible containing the electrodes. Both furnaces employ tuyeres, but for different purposes. In the Swedish furnace, gaseous products of combustion taken off from the top of the furnace are blown back into the crucible for the purpose of cooling the arched roof above the electrodes. In the Californian furnace, air is blown in to burn the carbon monoxide to dioxide in the shaft above the descending charge and thus preheat the charge. Dr. Richards' paper considers in an interesting manner a combination of blast furnace and electric furnace; he really suggests to modify the ordinary blast furnace, so as to add in some way supplementary electric heat at the tuyeres in order to increase the economy of operation. In none of the papers the old suggestion of Dr. Héroult was mentioned to charge the iron ore and the reducing carbon separately into the furnace. In this case it would be possible to burn all the carbon to dioxide. But it seems that the practical difficulties have so far been unsurmountable.

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Naturally of far greater practical importance and of more general interest were the papers on electric steel making and refining. Every type of electric-steel furnace was discussed in one or more papers, and the program was truly international. The personal presence of Major Stassano, of Italy, and of Mr. Hay, of England, gave a particular charm to the proceedings. The immense interest that the iron and steel industry now takes in electric steel, was clearly indicated by the fact that every important steel concern of this country was represented by one or more representatives, who were evidently intently interested, but remained silent spectators. This silence was disappointing. Nor was there any cross-examination of representatives of one type of electric-steel furnace by representatives of other types. This was surprising in view of the competition which exists. Although there was, therefore, no real general discussion, the program of papers was so excellent and well balanced as to give a very good view of the present situation in this new and rapidly growing industry. The American Electrochemical Society may be well satisfied with the success of this symposium. More than one of the practical steel men remarked privately that they had to come to this society to learn something new about their own profession.

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Our report of the papers in this issue will be found so full that there is no necessity to discuss them here in detail. Only a few remarks may be made on the one paper, by Mr. Hibbard, in which a somewhat discouraging view was taken. To balance the program this paper was needed. A doubting Thomas in a crowd of enthusiasts is always useful. Mr. Hibbard's paper was suggestive and brought out good points. But this does not mean that we agree with the general view taken by Mr. Hibbard. He does not deny that the electric furnace can do certain things for steel, but he doubts whether the cost is worth the price. His argument is, for instance, that steel rails, if they cost more, should last longer; but that the manufacture of electric-steel rails is not yet old enough to permit a definite verdict. The best answer to the critical position assumed by Mr. Hibbard is the existence of over 60 electric-steel furnaces in commercial operation in different countries, and the fact that new furnaces are continually added. Though there would have been much justification in Mr. Hibbard's criticisms about a year or two ago, it seems to us they came now post festum.

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One thing should not be overlooked in estimating the commercial prospects of the electric-steel furnace. It is the fact that its introduction does not mean the scrapping of existing metallurgical plants. The electric furnace is not a competitor, but a supplement to existing plants. We can speak even more strongly. The electric furnace not only does not mean scrapping of old plant, but it seems destined to prevent the scrapping of old plant, as it promises to give a new lease of life to the converter. The general tendency of recent years has been away from converter steel toward open-hearth steel, and pessimists have already seen the beginning of the end of the converter. It is at this point that the electric process steps in, since the combination of the converter with the electric furnace should satisfy all reasonable requirements. This fact and the undeniable tendency of the times to demand better steel for general purposes, are considerations of utmost importance, if it is questioned whether the cost of electric-steel refining is worth the price. We hope our report in this issue will prove interesting, instructive, and suggestive reading.

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## Heat Transmission and Heat Insulation.

The laws of heat transmission in steam boilers, sketched in Dr. Nicolson's paper in this issue, should not be without interest to metallurgical and chemical engineers. Effective heat transmission is all-important for furnaces heated from the outside, just as effective heat insulation is needed for other furnace problems. (As a strange anomaly it may be mentioned in

parenthesis that the same material—fire clay—is now generally employed for heat insulation in fire brick and for heat transmission in zinc retorts.) The point which is very strongly brought out in Dr. Nicolson's paper and which is too generally and too easily overlooked is that the thermal conductivity of the walls and the temperature of the charge inside and the temperature of the air or water outside do not alone determine the flow of heat through the walls. There may be, and as Dr. Nicolson shows for boilers there is, a very considerable sudden temperature drop right at the two surfaces of the walls, and this temperature drop depends on the speed with which the charge, air, etc., are moving along the walls. If these "contact resistances" to the flow of the heat are not taken into consideration, calculation of the heat flow is liable to lead to very erroneous results.

## The Evolution of Furnace Design for the Fixation of Atmospheric Nitrogen.

The new process of the Badische Company for the fixation of atmospheric nitrogen is described in this issue in a very interesting paper by Dr. Schoenherr. In electrical and mechanical respects this new electric arc furnace is of almost ideal simplicity and may be considered as the limit of a long series of trial designs. First the endeavor was to subdivide the electric discharge into as many small discharges as possible; this was the era of the spark furnace, as exemplified by the historical Bradley-Lovejoy furnace. Then the necessity became manifest to simplify the construction and to use larger units, and inventors gave up the spark furnace for the arc furnace. This meant a great simplification, and the Birkeland-Eyde furnace with its arc disk, produced by exposing the arc to an alternating magnetic field, became the first commercial apparatus, in which the fixation of atmospheric nitrogen by electric discharges through air became a commercial success. It is a large unit and a comparatively simple apparatus, but the necessity of having a big electromagnet involves a certain clumsiness. Compared with this, the furnace of the Badische Company is of still greater simplicity. It consists of nothing but a number of coaxial iron tubes, with a water-cooled top and an iron electrode in the bottom. From an electrical standpoint, the possibility of producing a quiet alternating-current arc of some 5 m or 7 m length (16 ft. to 22 ft.) is most surprising, and the method of producing this quite long arc by means of a helical air curent (which is thereby changed into a gas mixture containing nitrogen oxides) is as simple as ingenious. It is hardly possible to imagine anything simpler electrically or mechanically, and Dr. Schoenherr must be sincerely congratulated on the success of his work.

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Nevertheless, Dr. Schoenherr's paper will be found disappointing in one important respect. It is interesting enough to learn that the new furnace is superior to the Birkeland-Eyde furnace not only in giving a higher efficiency (that is, more nitric oxide per kw-hour), but also a more concentrated gas mixture (that is, more nitric oxide per cubic foot or per pound of gas mixture). The first point is important for the economy of power utilization, the second point for the economy of the subsequent transformation of the gas mixture into nitrite or nitrate or nitric acid. But why not give exact figures, as the Birkeland-Eyde people have done? Only on the basis of exact figures it will be possible to judge whether the process has outgrown the peculiar conditions of the country of its commercial birth—Norway—with its exceedingly cheap power. It almost seems so, since it is reported that the Badische Company intends to use the Alz water-power in Germany for operating the process. For the present, however, we can only repeat what we have said more than once before, that the success of such processes in Norway—with a cost of the electric hp-year somewhere between $4 and $8—is no criterion whatever for forming an estimate on the possibility of commercial success in this country.

## Leaching Processes in General.

So many instances of wet processes, or rather proposed wet processes, occur either as disclosed by the records of the Patent Office or by the reports published in the technical press of experiments, that a few general remarks about the difficulties of hydro-metallurgy are not at all superfluous. The field is very attractive. It is apparently a simple matter to treat an ore with a chemical and extract its value thereby. But the meager results from the vast amount of experimental work done do not justify the first impressions that are given to the casual observer. Possibly because the first experimental work can be done so very cheaply in the ordinary analytical laboratory and its allurements are so many, there will always be much experimental metallurgical work in the wet way.

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Metallurgical processes can be divided into two classes: first, those that work on ores and, second, those that work on crude metallurgical products, such as matte or impure bullion. Wet processes of the second class have had a considerable degree of success. For example, the electrolytic refining of "converter" copper, "base" lead bullion, Doré silver bullion, are each hydro-metallurgical processes that not only compete with pyro-metallurgical processes, but have in some instances entirely superseded them. Wet processes of the first class— that is, working on the ore or concentrate direct, have in only two cases decided superiority over smelting processes. These two are the cyanide process for gold ores and the leaching of bauxite by caustic soda for the production of alumina to be used in the electric decomposition cell. We would hardly call the amalgamation of gold ores by mercury a wet process, as the ore is not leached at all. The other processes that come in this category, but are of minor importance, are the chlorination of gold ore, the hyposulphite lixiviation of silver ore, and the "patio" process likewise used on silver ore. The first is used largely on Cripple Creek gold ores and the latter two chiefly on Mexican silver ores, when a silver mine is remote from smelting centers. The leaching of copper ores by weathering is practiced largely by the Rio Tinto Company in Spain. The precipitation of copper-bearing mine water at Butte is of some importance. But in examining all the above-mentioned cases, it can be readily seen that of all leaching processes the cyanide process alone is of supreme industrial worth. This is due to the inherent advantages of a low-cost solvent that attacks chiefly the valuable constituent of the ore rather than its common mineral impurities, to a cheap and effective precipitant, and to the fact that it operates well on crushed tail-

ings from another cheap process—the amalgamation process.

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The hydro-electric processes for silicious oxidized copper ores and also for complex lead-zinc ores, especially when combined with electrolytic deposition, are apparently attractive. But, while their name is legion, their practical or commercial success is little. Of all the countless proposals for leaching copper ores we can count only on two in this country that have any degree of importance. And there are no successful lead-zinc wet processes, though the field for them is wide, because of the millions of dollars of zinc wasted each year by the lead smelters of this country.

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The reason for all this is obvious to the competent metallurgical engineer. Leaching experiments on a small scale give rarely any criterion of results to be expected on a large scale. And also the amount of power for the electrolytic deposition of one ton of metal out of a weak solution against an insoluble anode is large. So the cost of deposition is high and the capital outlay for power house and vat house enormous. Besides there are many possible and unexpected impurities in the ores that are soluble or at least partially so in the different reagents used and quickly foul the solution. Thus, as Mr. D. H. Browne says, the initially good chemical condition cannot be cheaply maintained. In short, there are many basic reasons why wet processes for base metal ores die in the borning. If we compare them with methods using the reverboratory furnace or the blast furnace, with the addition of the proper fluxes, we see that we have in the heat treatment the chance to increase the temperature, or to change the charge, and that these changes enable the reaction to proceed easily. In a wet process it is usually a question of one or two new reactions and three or four mechanical processes to regenerate the solution, when a new impurity is formed. The pyro-metallurgical process is simple and powerful. The hydro-metallurgical process is complex and weak.

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It is to be doubted if the cyanide process in the Rand could compete with copper smelting and recovery of the gold in the electrolytic refining, were it near a large copper camp with plenty of ferruginous copper ores and with a cheap coke supply. The result would be the same as at Cripple Creek. The blast furnace takes what ore it wants and the leaching plants have what is left. We do not wish to discourage any inventor of a wet process, for probably they have already discouragements enough. But it is well to look the facts in the face. Any wet process can only succeed in its peculiar niche where its inherent advantages outweigh its inherent disadvantages. In a wet process the motto "tout bien ou rien" must apply. In short, a new wet process must resemble in neatness and effectiveness the cyaniding of gold or silver ore or it need not "apply at the gate."

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## Mining Accounts.

We have pointed out several times in these columns the fact that in computing mining costs quite often little attention is paid to the cost of development and exploration, and that while the actual breaking the ore in the stopes is usually a cheap

process yet it forms only a small proportion of the total cost. The largest and most variable factor is the finding of the ore and the amortization of the requisite plant to put the ore in commercial form. These often triple the cost of mining pure and simple. With modern corporate finance, an accurate system of accounts and publicity are now demanded of corporations by the investing public. In fact, it is a healthy sign of the times that this is better realized each year. And mining companies should be no exception to the rule.

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Mining accounts are, of course, most difficult to reduce to a logical system of distribution of costs, because the amount of ore to be extracted during the life of the mine as well as the costs of extracting the ore, and the profits therefrom, is dependent on many various and uncertain factors. In this it resembles the accounting of experimental work. Nevertheless, the subject is being attacked nowadays in a more proper manner than heretofore. This country can learn much from England in this respect. There, the methods of the high-class companies engaged in financing and developing mining properties are conservative, yet conservative with a conservatism well-tinctured with engineering optimism. The result is that mining is on the whole on a more satisfactory and business-like basis, and wild-cat concerns are much less in evidence in England than in this country. There, the risk is eliminated, or rather the risk is reduced to known terms. And by engaging in a number of enterprises where the average chance for profit outweighs the average risk, probability greatly favors success.

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Naturally, in almost every mine a large amount of money must be spent in finding the ore and this expenditure must be amortized by the company to enable the company to get first a new dollar for an old one. After the cost of development has been met the profits are to be recorded. The time allowed for amortizing the exhaustion of the ore in the mine depends on geological and commercial conditions. This is a matter of technical and business judgment in estimating the life of the mine. In any event, it should be noted that once a mine is developed, the proper policy generally should be to mine the ore as rapidly as possible, for the interest charges on the value of the ore in the ground are a proper charge against the absolute cost of production.

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In an investigation of any kind, it is often well to take a case where the point to be investigated is seen in exaggerated form. In considering the question of proper charges for new exploration of the mineral veins, the records of any of the large companies operating in the Temiskaming silver district are suggestive. Here the cost of producing a ton of silver ore—for the ore of the "Cobalt" camp is, commercially considered, a silver ore—shows itself to be very high, for the veins are exceedingly narrow. Indeed, veins less than 2 in. wide are often worked there at a profit. This high cost per ton of ore is compensated for by the phenomenal richness of the ore. A vein 2 in. wide assaying 2000 oz. in silver is better than a vein 200 in. wide assaying 20 oz. One of the strongest of the companies operating in this district produced for the year 1908 approximately 3505 tons of ore which averaged 826 oz. of silver. The cost of production of the sorted ore totaled, in round numbers, $361,000, an average of $105. The cost of the actual

"stoping" the ore was but $16.22 per ton, and the sorting out of the ore was $5.90 per ton. Thus the actual mining operation and sorting cost only 21 per cent of the total. Diamond drilling, surface trenching and underground development cost $52.91 per ton of product, or 50 per cent of total cost. The remaining costs of $30 covered such items as assaying, engineering, insurance, taxes and general expense. Summarizing the three items of finding the ore, mining the ore, and overhead charges, it will be seen that their respective proportion was, respectively, 50 per cent, 21 per cent and 29 per cent of the total cost. Marketing the ore was included under a separate schedule, but here, too, a conservative course was taken, and smelter deductions for losses in treatment and smelter tolls were charged against the production of an ounce of silver, the total cost being 20.7 cents per ounce of silver mined.

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Looking into the above, we can see that the ore could have been produced very cheaply, had no development work been done. Indeed, practically half the expense charged against the mining was laid out in finding new ore. If the amount of new ore found by this exceeded the ore extracted, the operation was profitably done. And with a proper knowledge of geological conditions this was attained. Hence, the great importance of engineering and managing ability is seen. Accordingly, it can be laid down as a fact that the costs of any mining company, producing rich ore or low-grade ore, should be analyzed by the interested parties and special attention should be paid to the amount of new work done, and the results obtained from this expenditure. When complete reports are made and the accounting is accurate and honest, mining finance will have less of the aroma of the racing stable about it than it has at present. Finally, let it be said that while mines die as individual men die, a mining company should live as a family lives. For when one mine is being exhausted, another mine ought to be found to take its place. When such a course is honestly and intelligently pursued, the financial returns are most attractive.

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## "Problems of To-Day."

The growth of the iron and steel business has depended in the past on the existence of high-grade raw materials, pure coking coals and rich Bessemer ores. These items of national mineral wealth were, when collected together, in the major part *raison d'être* of the United States Steel Corporation. Mr. Carnegie in taking, in exchange for his steel plants, a first mortgage on this real estate made security doubly secure. For a steel works will depreciate with the advance in the art, whereas raw materials of the first grade appreciate with the growth of business. Mr. Carnegie has ever seen clearly the broad principles of political economy. And he has applied them to his business practically. In his latest book, "Problems of To-Day," he has enunciated several broad principles of social science. As he was both practical and theoretical in the conduct of business, all of his views on the questions of national life deserve respect and attention. Especially to the point is his critique on "Socialism." It is sane, common-sense like, and expressive of the highest side of individualistic humanitarianism. Substitute for crass and ignorant selfishness an enlightened self-interest and you have a state regenerated. Naturally, the words of the head of the firm of "forty partners" are most eloquent on the subject of partnership and profit-sharing. Mr. Carnegie gained his great wealth not by most careful attention to details—that was left to the partners—but chiefly by the use of a projected imagination. He applied to the practice of his business the several theories of his great countryman, Adam Smith. He may be criticized in many ways—for who may not be?—but considered in its entirety, his career is typical of the best of the American multimillionaires.

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The same care that was used in making his money work efficiently in business is now used in his philanthropy. He uses the same practical manner of making the money when passing out of his hands do the maximum that he did when he let Captain Jones built his "giant mixer." Consider the Carnegie system of libraries. In the first place, his libraries give pleasure and instruction to the multitude throughout the continent. But we opine his thought not this so much as to develop the exceptional youngster—the original mind amid thousands—which mind having the clear sight and independence of genius needs only the chance to read the philosophy of the ages, to make up his own philosophy applicable to the present. This, we believe, is due to Mr. Carnegie's sympathy for minds like his own.

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We can further adduce the Carnegie Institute where pure scientific research directed along commercial channels—the words are not paradoxical—has already helped much metallurgy, medicine, and general technology. This was also wise and efficient giving. Mr. Carnegie's donation to the United Engineering Societies with the Engineer's Club adjoining is a sane way to bind the professions together for the common good. Possibly the greatest gift, measured in direct benefits to the higher and intellectual side of American life, was the Carnegie Foundation for the pensioning of college professors. This has had two distinct spheres of influence. In the first place, the annual report gives many data concerning the academic life here and abroad and lays down the abstract laws of higher education in this country as based on the facts. The second result is to assure a body of men, whose whole life is in the ideal, of the fact that they will not suffer materially in their old age. Thus the dignity and standing of the college professor is raised. Also its attraction to the young as a career is increased. Moreover, it allows the professor the leisure at the end of a long life a chance to produce his "magnum opus." This opportunity has been taken advantage of in one instance already, and a notable addition to Shakespearana is a concrete result. We think this is obtaining the maximum of national good at a minimum of expense.

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We may be open to the charge of unduly praising Andrew Carnegie, but a man's work is, indeed, above himself, and judging by results, we believe that he practices what he preaches. We see ever the same rare intellect in obtaining a maximum of return, be it in absorbing dollars or in distributing dollars for the benefit of the social organism. The attempt to attain the maximum of efficiency to make the best of the best that there is in life, is the problem of the twentieth century. Has any one attacked it more intelligently than Andrew Carnegie?

## Summer Meeting of the American Chemical Society

The summer meeting of the American Chemical Society will be held in Detroit, Mich., from June 29 to July 2 inclusive. On the previous day a business meeting of the council will be held. The meetings of the sections and divisions will be held on Tuesday and Wednesday, June 29 and 30, and on Friday, July 2, in the Central High School, which has ample facilities.

On Tuesday evening a complimentary smoker will be given by the Society of Detroit Chemists to the members of the American Chemical Society.

On Wednesday afternoon the members will inspect the works of Parke, Davis & Company, to be followed by a lunch and a moonlight boat ride on the Detroit River, complimentary to the visiting chemists from this firm.

On Thursday the members will take special cars to the University of Michigan at Ann Arbor, where they will be the guests of the University of Michigan for the day, returning to Detroit in the evening for the usual banquet. The program will be continued on Thursday at the University of Michigan and will consist mainly of special papers of wide general interest.

On Friday the sectional and divisional programs will be continued and excursions taken to manufacturing plants in Detroit.

The headquarters for the meeting will be at the Hotel Pontchartrain. Details in regard to this hotel and other hotels in Detroit may be obtained by addressing the secretary. It is suggested by the local committee that it is very necessary to make hotel reservations in advance, as Detroit is liable to be crowded at this time.

Special arrangement is being made for the entertainment of ladies who accompany members.

## New York Meeting, American Institute of Chemical Engineers.

The first semi-annual meeting of the American Institute of Chemical Engineers will be held in New York City from June 24 to June 26.

The first day, Thursday, June 24, will be devoted to the reading and discussion of papers; the session to be held at the Polytechnic Institute, in Brooklyn.

The following papers have been announced:

"The Utilization of Low-Grade Fuels in the United States," by O. K. Zwingsnberger.

"Creosote Oil from Coal-Gas Tar," by Dr. S. P. Sadtler.

"Automatic Acid Egg," by Richard K. Meade.

"Some Experiments on Case-Hardening of Steel with Gases," by Dr. J. C. Olsen.

"New York Metropolitan District as a Center for Great Industries," by Dr. C. F. McKenna.

"Methods of Clay Control," by J. G. Dean.

A number of additional papers will be presented during this session, of which the exact titles have not yet been announced.

For Friday and Saturday a number of very interesting excursions have been arranged. It is understood that chemical engineers engaged in similar work will not attend these excursions unless the same courtesy of inspection is extended from their own plants.

The program for Friday, June 25, is as follows:

9:30 a. m.—Excursion to the Atlantic White Lead & Linseed Oil Works, foot of Gold Street, Brooklyn, N. Y. (Manufacture of white lead, linseed oil, lead pipe and sheet lead.)

11:30 a. m.—The National Lead Company's steam lighter *Atlantic* will convey the members of the institute and their guests up the Hudson. Lunch will be served on the lighter.

1 p. m.—Excursion through the Edgewater plant of the Corn Products Refining Company. (The manufacture of glucose, starch and corn by-products.)

3:30 p. m.—Excursion through the plant of the Warner Sugar Refinery Company, at Edgewater. The return trip will be made on the steam lighter *Atlantic*, and a subscription dinner will be held in the evening.

The program for Saturday includes an excursion to the Standard Oil Company's plant at Bay Way, N. J. (refining oil and by-products). Various points of interest in and around New York will also be open for inspection, among them the Brooklyn Navy Yard, the Hudson & Manhattan Tunnel plant, the plant of the Consolidated Gas Company at Astoria, L. I., the Manhattan Bridge (now nearing completion), the Pennsylvania Railroad tunnels and improvements, the DeForest wireless telegraph installation in the tower of the Metropolitan Life Building, etc.

The hotel headquarters will be at the Hotel St. George in Brooklyn. Dr. J. C. Olsen, of the Polytechnic Institute, in Brooklyn, is the secretary of the American Institute of Chemical Engineers.

## The Iron and Steel Market.

A distinct upward trend in iron and steel prices manifested itself in May, the natural sequel to the radical reductions involved in the abandonment of the price maintenance policy in February and the increase in buying during March and April. Bars, plates and shapes advanced a dollar a ton about May 10, following a like advance in the closing days of April, and the market thus became established on the basis of $1.20 for bars and $1.30 for plates and shapes. These are the prices made immediately after the market was declared open Feb. 18 last, there having been a further decline of $2 or more a ton thereafter.

Wire products were reduced May 1, by $7 a ton on wire nails, $8 on plain wire and $10 on barb wire. The reduction had long been anticipated, being a part of the general reduction involved in the adoption of the open market policy. It was delayed because the spring business in wire was well under way. The reduced prices of May 1 were $1.40 on plain wire, $1.60 on nails, $1.60 on painted barb wire and $1.90 on galvanized barb wire. The cut was made a deep one in order to stimulate buying, and the move was an entire success. The mills accepted orders only for early shipment, practically as early as they could make, and in a fortnight had booked all the business they wished at the extreme prices, an advance of $2 a ton being accordingly announced, effective at the close of business, May 15.

Early in May an advance was made by the steel interests in light rails, the heavier sections being advanced about $4 a ton and the lighter sections $5 to $6. The rerolling mills had practically given up the competition.

While technically May showed a decline in wire products, the reduction was a delayed one, while the advance was in keeping with the trend of the market. Thus it may be said that in May bars, plates, shapes, light rails and wire have been advanced. These lines comprise between 55 and 60 per cent of the entire finished steel output, but it must be remembered that the price of standard rails was not brought in question. The decision to throw the market open in February distinctly excluded rails. They were not reduced and therefore could not be advanced, and as they constitute about 20 per cent of the total output, the lines which were advanced in May constitute between 70 and 75 per cent of the finished steel products, the price of which has been in question.

The advances made are therefore important, but they must be taken in their bearing. They merely remove the extreme of the reductions, and leave prices very low in comparison with prices ruling in 1907.

One important reason why these advances were made was that buyers were disposed to contract more freely than suited the purpose of the mills; the rate of buying was quite in excess of the rate of consumption, and some purchases were largely of a speculative character. It was desired to discourage such buying, and to sell material only in proportion as it was being consumed.

The tone of the steel market has passed from extreme pessimism to extreme optimism, and extreme views are usually erroneous. It is obvious that such is the case in this instance. The February price break occurred in a month when pig-iron production was at the greatest rate recorded since October, 1907, about 22,500,000 tons a year, while in April production declined to a rate of 21,400,000 tons a year, and May production is not likely to have attained the February rate. It is improbable that buying in the next two or three months will be nearly as heavy as it has been in April and May, nor is it likely that production, despite the good buying that has occurred, will greatly increase.

The railroads have not participated in the general buying to the usual extent. It is estimated that they have been buying less than half as much as in 1906 and 1907, and it is fair to estimate that in those years they took 40 per cent of the entire iron and steel output. The 1906 pig-iron production was 25,300,000 tons, and the 1907 production, had it not been for the slump in the two closing months of the year, would have been about 27,300,000 tons. The mean of these is 26,300,000 tons. Allowing the railroads 40 per cent of this and estimating that their purchases have declined 50 per cent., the loss is 5,260,000 tons, deducting which leaves 21,000,000 tons. Now the fact is that pig-iron production from Jan. 1 to May 1 was at the rate of about 21,700,000 tons. This is somewhat startling. It would hardly be assumed that buyers other than railroads have been taking a larger tonnage than in 1906-7. They have probably taken nearly as much, while there has been some accumulation of material. This should preclude any great increase in production. It is known that in many cases jobbers and manufacturers have been replenishing stocks, under the stimulus of very low prices, and the next gain to the steel trade must be through an actual and large increase in ultimate consumption. There is no prospect that the railroads will largely increase their purchases.

### Pig Iron.

The pig-iron market has shared the optimism prevailing in the finished steel trade. Prices have been advanced sharply in the central West, and moderately in Virginia and the East. Sales have been fairly large. Eastern steel works have bought 80,000 tons or more of basic, chiefly for third-quarter delivery, while central Western steel works have bought probably half this tonnage, and they have taken also about 25,000 tons of Bessemer. The central Western sales, particularly of Bessemer, have been chiefly for May and June delivery, and the market has advanced sharply. Bessemer iron, quoted at $14.75, valley, or $15.65 Pittsburgh, in April, declined to $14.50, valley, several sales of 500 tons and less being made at this price. The buying started, about the 20th of the month, with a lot of 10,000 tons of prompt at $14.50 and within a few days the market had advanced to a minimum of $15, valley, or prompt, with $15.25 to $15.50 demanded for third quarter. Basic is about $14.50, valley, for prompt and third quarter and foundry and malleable about $14.75, valley. The Southern market remains at $11.50, Birmingham, for third quarter, but the $11 prompt iron does not seem to have entirely disappeared.

### Billets and Sheet Bars.

The market is firm, but transactions are light, as consumers are well covered by term contracts, on which deliveries have improved. Billets are $23, Pittsburgh; $24.50, Philadelphia, and $24, Chicago, forging billets being $2 higher. Rods were $29 for Bessemer and $30 for basic open-hearth at the close of April. With the sharp reduction in wire products May 1 a regular reduction of $2 was made in rods, but mills indulged in sharp competition and sold some large tonnages at $1 to $2 less than the open market. With the advance of May 15 in wire products rod prices were advanced to $29 for Bessemer and $30 for basic open-hearth, at which figures the market is firm.

Finished steel prices, f. o. b. Pittsburgh, are as follows:

Steel bars, $1.20, base.

Iron bars, $1.30, base.

Plates and shapes, $1.30 basis.

Plain wire, $1.50, base; wire nails, $1.70, base; painted barb wire, $1.70; galvanized barb wire, $2.

Standard rails, $28; light rails, 40-lb. and 45-lb. sections, $26, in carload lots.

Sheets, 28 gage, black, $2.25; galvanized, $3.25; on attractive orders, 5 cents per 100 lb. less.

Tin plates, $3.40 for 100-lb. cokes.

Merchant steel pipe, ¼ in. to 6 in. inclusive, nominally 80 off in "jobbers' carloads"; actual inside price, 81 and 5 off.

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## Adoption of the Heroult Furnace by the Aug. Thyssen Company in Germany.

The "Deutscher Kaiser" Steel Works and the Mülheim Steel Works, owned by the August Thyssen Company, the largest German steel and steel-rail works, have closed a contract with the German owners of the Héroult patents.

Two large Héroult electric furnaces will be installed at the Deutscher Kaiser Works to purify and refine steel for rails from Thomas converters. Another furnace will be installed at the Mülheim works, and additional Héroult furnaces are to be constructed as soon as the foregoing are in operation.

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## In Memoriam—Henry August Hunicke.

On Monday, April 5, 1909, Henry August Hunicke died in the prime of his life in St. Louis.

Mr. Hunicke was born in St. Louis, Sept. 21, 1861. He graduated from Washington University in 1882 as engineer of mines. He then went to Germany to study at the Institute of Technology of Dresden, devoting himself especially to technical chemistry and gas analysis under Hempel. After a sojourn
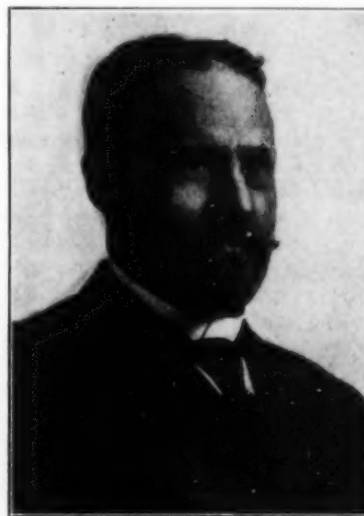


HENRY AUGUST HUNICKE.

of somewhat over a year in Europe, spent in travel and study, a period rich in observation, and to which he always referred with the keenest pleasure in after life, he returned to the United States and entered the chemical laboratory of the Bessemer Steel Works at Wheeling, W. Va.

But he soon came back to his native city, St. Louis, where he took charge of the analytical and assaying laboratories of the St. Louis Sampling and Testing Works, which had been established by Professors H. A. Wheeler and Wm. B. Potter.

After having been interested for some time in a new process of zinc melting, which did not lead to lasting results, he be-

came in 1894, adjunct professor of applied chemistry at Washington University, a position which he held until 1898.

He then became chemist to the Anheuser-Busch Brewing Association. In this position he found a field of greatest and widest activity. For instance, his investigation of the methods employed in the boiler house of the brewery and the recommendations that he subsequently made, rendered possible the saving of nearly $10,000 in the annual fuel bill. In the interest of Mr. Adolphus Busch he also began to pay special attention to the rubber industry and the manufacture of synthetic rubber.

In 1908 Mr. Hunicke severed his position with the Anheuser-Busch Company and established himself as independent consulting chemist and chemical engineer in St. Louis.

Mr. Hunicke was a member of the American Institute of Mining Engineers, of the American Chemical Society, of the Society of Chemical Industry, the Deutsche Chemische Gesellschaft, and the St. Louis Academy of Science. He was always active and willing to help when he saw an opportunity to promote science. He has been a very good friend of this journal. He was one of the founders of the St. Louis Chemical Society in 1903 and of the American Institute of Chemical Engineers in 1908. In the Institute he took great pride and he expected great results from its formation; he was a vice-president and the editor of the journal of the Institute at the time of his death.

## American Foundrymen's Association Meeting.

The 14th annual meeting of the American Foundrymen's Association was held in Cincinnati, Ohio, beginning on May 18. In spite of the period of depression in the foundry industry the attendance was exceedingly good, being well above 2000. The regular exhibition of foundry machinery and appliances stimulates, of course a large attendance, and this year's exhibition, in charge of the Foundry & Manufacturers' Supply Association, was certainly very interesting.

From the report of the secretary, Dr. Richard Moldenke, we quote the following interesting points:

"Probably two lines of foundry economy have been more or less studied during the last year. They are the permanent mold, with the elimination of waste where success has been obtained, and continuous melting with the resulting increase in the output of existing plant units.

"The correspondence passing through the secretary's office has reflected the above mentioned tendencies rather sharply, and would seem to indicate that before long we will find foundrymen understanding their cupolas better and manipulating them to suit floor conditions, instead of vice versa. The permanent mold will probably still further special in the foundry, gradually drawing from the general trade certain castings, which have to be made very cheap and in quantity. Separate plants of comparatively small size, but enormous capacity, fully equipped to do just one line of work, turning scrap into finished castings of uniform composition and specified service requirements, will be located where the proper commercial conditions obtain and another chapter will be added to the growing volume on modern foundry practice."

An extended discussion on continuous melting resulted from the paper of Mr. S. D. Sleeth, on continuous melting in the foundry of the Westinghouse Air Brake Company. He gave an interesting account of their experience at Wilmerding, Pa. He summed up his experience in the advice: "See that the coke bed is burning even all around, then charge just as you would for an ordinary run, allowing an extra amount of coke for the dinner hour. After running about one hour, open the slaghole and keep it open, except during the dinner hour. Use about 40 to 50 lb. of limestone to 1 ton of molten metal; better use too much than too little. Have the cupola shell large enough, as it is easy to put in an extra lining for smaller heats."

To make continuous melting and pouring economical, Mr. Sleeth thinks the daily amount of work of the foundry should be at least 40 or 50 tons. The economies of the system, he explained, consist in getting back the sand in 20 minutes after the castings are taken out, in getting back the flasks promptly, and in the repeated use of sand and flasks on the same conveyor.

The other prominent feature of the convention, a discussion on permanent molds, was introduced by an excellent paper by Mr. Edgar A. Custer, president of the Tacony Iron Company, of Philadelphia.

Other papers presented at the meeting were by Mr. J. S. Whitehouse, of the Bonney-Floyd Company, of Columbus, on the side-blow converter for steel castings; by Mr. W. M. Carr, on the design of a small open-hearth furnace (500 lb. to 2-ton); by Mr. R. K. Meade on pulversized coal for foundry purposes; by Prof. B. Stoughton, of New York, on the cost of steel castings; by Prof. John J. Porter, of the University of Chicago, on chemical standards for iron castings.

Before the American Brass Founders' Association, the secretary, Mr. W. M. Corse, discussed the red brass ingot and the improvements in its manufacture that have led to its extensive use in castings from which a few years ago it was debarred. Mr. F. W. Reidenbach, of the Genesee Metal Company, of Rochester, N. Y., discussed the possibilities of utilizing the waste heat in foundries. At the works of the Genesee Metal Company a steam heating plant is maintained which heats the company's offices with the waste heat of only two No. 200 crucible furnaces; this represents an annual saving of $300 in fuel.

Mr. C. H. Wilson, of the Wilson-Maeulen Company, of New York, pointed out that, while all steel men now recognize the great importance of pyrometers, brass founders have shown little interest so far to their own disadvantage. There is, however, still one difficulty to be solved in the use of electric resistance or thermo-electric pyrometers in brass foundries; that is the construction of a protecting tube which can be put in molten brass many times without frequent repairs or renewals.

Mr. Charles T. Bragg presented a paper on brass melting. Mr. E. H. McVeen on melting brass turnings in the oil furnace, Dr. W. D. Bancroft on the tensile strength of aluminium-zinc alloys.

Mr. Arthur T. Waterfall is the new president of the American Foundrymen's Association; Mr. William R. Webster, of the Brass Founders' Association; Mr. Eugene W. Smith of the Associated Foundry Foremen, and Mr. F. N. Perkins of the Foundry Supply Association.

The 1910 convention will be held in Detroit.

## CORRESPONDENCE

### Berthelot Monument.

*To the Editor of Electrochemical and Metallurgical Industry:*

SIR:—On March 25, 1907, Marcelin Berthelot, the great French chemist, and his wife were given a national funeral and accorded sepulture in the Pantheon.

It is now proposed to erect a monument to his memory by international subscription. M. Emile Loubet, former President of the Republic, was president of the committee of organization and now M. Armand Fallières, President of the Republic, is president of the committee of honor.

It would be but a just and opportune recognition of Berthelot's services to science in general and to electrochemistry in particular if American investigators shared in this worthy movement.

Subscriptions should be forwarded to M. Charles Goudchaux, treasurer of the committee, 16 Rue de Miromesnil, Paris, 8e, France.

Subscribers of 10 francs and over will receive a special copy of the "Livre d'Or de Berthelot," which will be published later.

NEW YORK CITY.      CHARLES A. DOREMUS.

## The Process of the Badische Company for the Fixation of Atmospheric Nitrogen.

In a recent paper before the Berlin Electrical Society Dr. SCHOENHERR gave an interesting review of the researches which have been carried out by him in conjunction with Mr. Hessberger since the end of the nineties, for the Badische Anilin und Soda Fabrik in Ludwigshafen, Germany. The complete paper of Dr. Schoenherr has now been printed in *Elektrotechnische Zeitschrift* of April 22 and 29. The following account contains all essential technical details:

In 1905 they succeeded in inventing a new electric furnace for combining the oxygen and nitrogen in atmospheric air by means of an arc discharge. The characteristic feature of their furnace is the use of a long, absolutely quiet, and stable arc. In their early experiments they became convinced that it is absolutely impossible to pass any large quantities of air through an arc in a direction perpendicular to the plane of the arc (though this has been the endeavor of many inventors). In all such experiments only a small portion of the air is subjected to the effect of the electric discharge and the resulting gases are therefore very dilute with respect to nitrogen oxide.

Higher concentrations of nitrogen oxide in the gases are obtained, however, if the air is passed along the surface of a quiet arc, although this is more easily said than done. An open arc of great length is exceedingly unstable and is liable to be extinguished at any moment, even if one imagines to have avoided the least bit of an air current. But to get a good energy efficiency it is necessary to bring large quantities of air in contact with the arc, and, therefore, to use a high speed of the air current. That means that the arc will be continually in danger of being extinguished.

The alternating-current arc is in any event of a very unstable nature, while a direct-current arc is much easier to be maintained. Under the present conditions of electric engineering, however, alternating current must be applied. These considerations indicate difficulties which seemed almost unsurmountable, but which have been overcome in a very simple way. *If the air is passed in a helical path around the arc the alternating-current arc loses its unstable character and becomes as quiet as a candle; it is then possible to include it within a rather narrow metallic tube without running the risk that the arc gets in contact with the walls of this tube.* The Badische Company now uses exclusively arcs within the center of a helical air current.

The apparatus is very simple. It is only necessary to arrange an electrode in the interior of a vertical tube near the bottom, but insulated from it, and to pass air through the tube in a helical path upwards, and then light the arc in some way. The simplest method of lighting the arc is as follows: The space between the insulated electrode and the walls of the tube is made very narrow at one point so that a spark will pass over on open circuit under the influence of the impressed potential difference. As soon as this happens the air current drives the one end of the originally very short arc upwards along the walls of the tube. The arc thus gradually becomes longer and longer, burning within the center of the tube. Its upper end is at a considerable distance above the insulated electrode at the lower end. At the upper end the gases are so hot that they have sufficiently high conductivity to permit the passage of an electric charge through them.

Since the arc is always used in series with an inductance coil, the voltage drops during the burning of the arc by such an amount that no new discharge can occur at the narrow space at the bottom where the arc was originally lighted.

Fig. 1 shows diagrammatically the form of furnaces now being used by the Badische Company. It consists essentially of a number of concentric vertical iron tubes, one within the other. The electrode at the bottom is an iron rod $E$, adjustable within a water-cooled copper cylinder. Only the iron rod is consumed. Under the influence of the heat of the arc the iron becomes coated with an oxide layer which evaporates slowly; according to the progress of the evaporation, the iron rod is pushed upwards. The electrode consumption is almost of no importance as an expense, the cost is only a few pfennigs per kw-year. The electrode rods used last about 2000 hours or three months. A new rod is inserted by screwing it to the old one; this takes not more than 15 minutes.

The water-cooled copper cylinder surrounding the iron rod is sufficiently removed from the surrounding iron tube so that there is no danger of an arc passing over. To start the arc the artificial electrode $Z$ is provided which can be brought in contact with the electrode $E$. On removal, the arc starts and travels upward as described. The upper end of the arc always travels around within the water-cooled upper part $K$ of the iron tube through which the air is passed.

$G_1$ is a peep hole for observing the starting of the arc. $G_2$ and $G_3$ are peep holes for observing the upper end of the arc. In the 600-hp furnace at Kristianssand the arc has a length of about 5 m, while in the 1000-hp furnaces, which are operated at a higher voltage, it has a length of 7 m.

The arc plays in the innermost iron tube and through it the air is passed upward. This tube has an almost unlimited life, since only on the rare occasions of lighting the arc the arc comes in contact with this tube. The upper end of the arc plays as described inside the water-cooled tube $K$, revolving around, so that the wear and tear is also small. The upper water-cooled part is built separately so that it can be easily repaired. When in one case this part was removed after four months of operation very little wear and tear could be observed.

The air which is subjected to the high temperature of the arc is introduced near the lower electrode through eight holes, which may be more or less closed by means of the slider $S$. When the air enters through these holes into the innermost tube, it is already preheated. The path of the air through the furnace is indicated by arrows in Fig. 1. The air enters at $c$, rises upward in tube 2 and downward in tube 3 (being preheated in tubes 2 and 3), passes through the eight holes near the bottom into the innermost tube 4, where it is changed into a gas mixture containing nitrogen oxides. This gas mixture, after having risen to the top of the furnace, passes down again through the outer tube 1 and is withdrawn from the furnace through $d$.



FIG. 1.—DIAGRAM OF FURNACE FOR FIXATION OF ATMOSPHERIC NITROGEN.

The water for cooling the upper portion $K$ of the furnace enters through $a$ and leaves through $b$.

At the plant in Kristianssand in Southern Norway, which has been in successful operation continually since the autumn
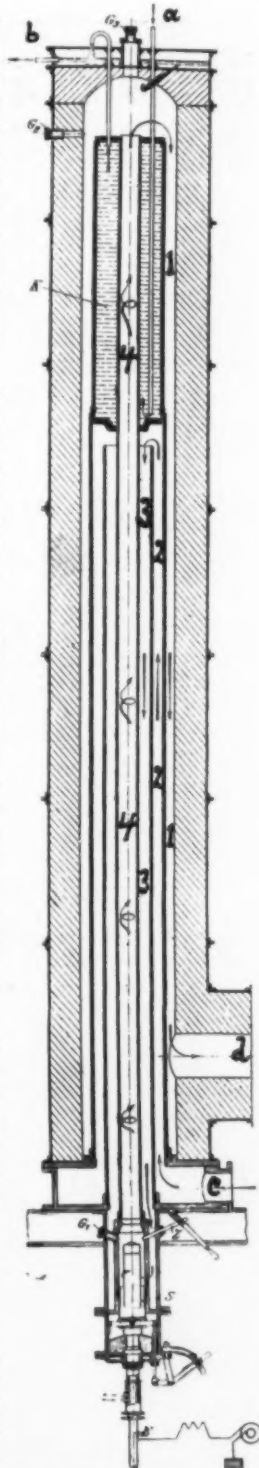
of 1907, three-phase currents are employed which are transmitted from a water-power station in the neighborhood at 25,000 volts. At the plant the voltage is reduced to 7200 (delta), the voltage per phase (star) being, therefore, 4200.

Three furnaces are connected in star. Since about 1300 kw are available each of the three furnaces is operated at about
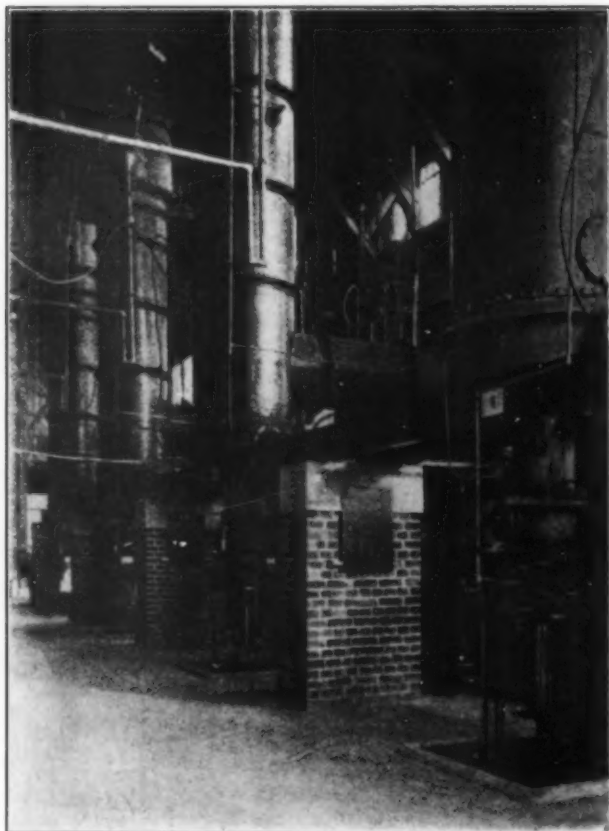


FIG. 2.—VIEW OF FURNACES.

600 kw. Occasionally 1000-hp furnaces have been in operation and furnaces of this size will be used later on exclusively. It even seems possible to operate with equally good success furnaces of 2000 hp.

The nitrogen oxide gases leave the furnace through a channel *d* which brings them to a steam boiler. This serves as a cooling device for the gases, while the steam produced is used later for concentrating the obtained solutions by evaporation.

The arcs are in operation continually and only in case of an accident are they extinguished—for instance, when there is a short circuit on the transmission line or when the air supply is suddenly changed.

The current and voltage curves are almost sinusoidal. The power factor is nearly unity and varies in the average between 0.93 and 0.96. This is thought to be due to the fact that essentially the same air particles form the electric current conductor during several successive periods of the alternating current. The resistance variations are, therefore, less than is usually the case with arcs. Although at every moment new cold particles of air enter into the zone of the arc, their number is small compared with the air particles already in this zone.

The fact that the air remains for a long period in contact with the arc is, therefore, not a disadvantage, as had been thought by some critics. In fact, the efficiency is not reduced thereby, since, as a matter of fact, this arc process operates with a higher energy efficiency than the process of Birkeland and Eyde.

It has long been recognized that two points are of essential importance to get a high efficiency; first, to produce a high

temperature (this is accomplished effectively by the arc); second, to cool suddenly the gas mixture which contains the nitrogen oxides in order to "freeze," so to speak, the equilibrium of the gas mixture corresponding to as high a temperature as possible (and, therefore, containing as high a concentration of nitrogen oxides as possible). This is most effectively done by means of the cold air which always surrounds the hot air in the center of the tube. The temperature of the gas mixture when leaving the innermost tube is about 2000° C. When leaving the furnace through the channel *d,* the temperature is 850° C.

The heat balance sheet of the furnace operation is interesting, although a little disappointing. The energy of the arc is completely changed into heat. Of this total heat, however, only 3 per cent is used for the formation of nitrogen oxides; 40 per cent of the heat is recovered in form of hot water; 17 per cent of heat is lost by radiation; 30 per cent is utilized in the steam boiler. And 10 more per cent must be abstracted by water cooling from the gases after their passage through the steam boiler. The steam heat is, of course, usefully employed for evaporation, so that no further fuel is needed in the process.

It might be possible to build the furnace itself into a steam boiler, but for practical reasons this idea has not yet been tried.

The process not only has a higher energy efficiency than other processes, but yields the nitrogen oxides in a higher concentration and this is of great importance for the purpose of absorption.

The nitrogen oxides can be absorbed by alkali solutions, like soda solution or milk of lime, etc., forming nitrites and nitrates. The resulting nitrite and nitrate mixture may be directly used



FIG. 3.—LOWER PART OF FURNACES.

as a fertilizer. The old statement that the presence of nitrites in the fertilizer has a deleterious effect on the plants has been proven to be wrong.

But the expense of the soda solution is prohibitive, and the use of milk of lime involves difficulties since when employing

ordinary absorption towers the hollow spaces in the same are liable to become clogged. More recently, Dr. Schoenherr states, they have overcome the difficulties of absorbing the gas mixture with milk of lime. They obtain thereby a calcium nitrite which has quite satisfactory properties. It has a high content of nitrogen, namely 18 per cent (against 15 per cent in Chile saltpeter and 13 per cent in "Norge saltpeter," made by the Birkeland-Eyde process).

It may be noted that it is not difficult to change the nitrite into a nitrate, if that should be necessary.

At the Notodden plant of the Birkeland-Eyde Company water is chiefly used for absorption, but this involves difficulties, and is quite a complicated process. Very large absorption spaces are required, and even then the last parts of the nitric oxide are absorbed by means of soda. Pure sodium nitrite is thus obtained.

At the Kristianssand works of the Badische Company the total nitrogen oxide gases are changed into nitrite, which is used in the Ludwigshafen works of the Badische Company. Formerly the nitrite was made by reducing Chile saltpeter by means of lead, but this method will now be given up. The market for nitrite is very limited, however, and the production of nitrite will play only a small part in the industry of the fixation of atmospheric nitrogen. With 1200 hp the whole world's demand for nitrite can be supplied.

Since in absorption with water the quantity of nitric acid formed will be greater the more of the nitric oxide has been changed into nitrogen dioxide, it is advisable to insert a so-called oxidation reservoir between the cooling devices and the first absorption apparatus. The gases are left for some time in the oxidation apparatus to change them as much as possible into nitrogen dioxide. Absorption of the gases by means of concentrated sulphuric acid is very easy, but is naturally limited in its applications.

Dr. Schoenherr thinks that further improvements may be hoped for with respect to the methods of absorption. A process patented by Schloesing is interesting. He extracts the nitrogen oxide gases from the air by means of hot briquets of burned lime. Nitrite is first formed, but in its continuous contact with air and nitrogen oxide gases it changes into nitrate so that finally calcium nitrate is directly obtained in solid form.

If the nitrogen gases are absorbed in water, as is done at Notodden, dilute nitric acid of 30 or 40 per cent is obtained. A higher concentration can hardly be obtained by direct absorption, and other methods must be resorted to for getting a higher concentration. A direct change of the nitrogen oxide gases into nitric acid could be easily accomplished with the aid of ozone. It would then be possible to produce also the anhydride $N_2O_5$. A cheap method of producing ozone would, therefore, essentially simplify the absorption problem.

A large plant, four times larger than at Notodden, is now in course of erection at Rjukan, being built by a combination of the Badische Company (with which are associated the Elberfelder Farben Fabriken and the A. G. für Anilin Fabrikation of Berlin) with the Norwegian Hydro-Electric Nitrogen Company, which has developed the Birkeland-Eyde process. The Rjukan plant will be the first common factory of this combination.

The development of the Rjukan water power has already proceeded pretty far. There will be available 250,000 electric hp. The development is carried out in two steps. For the beginning 10 turbines, each of 14,000 hp, are being erected, and this plant, together with its nitrogen oxide furnaces, will start operation in 1910.

The Badische Company has also acquired the water powers of Matre and Tyn in western Norway. After the development of all these water powers there will be more than 400,000 hp available in Norway for the fixation of atmospheric nitrogen. The Badische Company also intends to erect a plant for the same purpose in Southern Germany, where the water power of the Alz River will be utilized, giving 50,000 hp.

In the conclusion of his paper Dr. Schoenherr emphasizes that this new industry needs very cheap power, but nothing else. This industry may be carried out successfully even where other industries do not exist. While the cheapness of power is the chief requirement, this industry is able to consume practically unlimited quantities of energy, because there is a large and continually increasing demand for its products—nitrates and nitric acid.

Dr. Schoenherr thinks that one may prophesy a great future for this new industry; while power cost is the main item of the cost sheet, power will be available at the same price in future times, while wages and the price of fuel and other raw materials, so far more important in other industries, are steadily increasing. It may be, therefore, expected that in course of time conditions will become naturally more favorable for this new industry.

## A New Diaphragm Cell for Production of Alkali and Chlorine.

At the meeting of the Faraday Society, held on April 27 in London, a paper by Messrs. F. G. DONNAN, J. T. BAKER and B. P. HILL was read on experiments on the current and energy efficiencies of the Finlay electrolytic alkali-chlorine cell.

This cell, diagrams of which are given in the adjoining illustrations, was patented in 1906 by Messrs. Archibald and Robert Finlay, of Belfast. It is characterized by the use of a double diaphragm and central brine compartment, whereby the brine solution continuously flows under head from the central compartment through the diaphragm to the anode and cathode compartments, and from these to suitable outlets.

By a suitable arrangement of overlapping holes and slots any
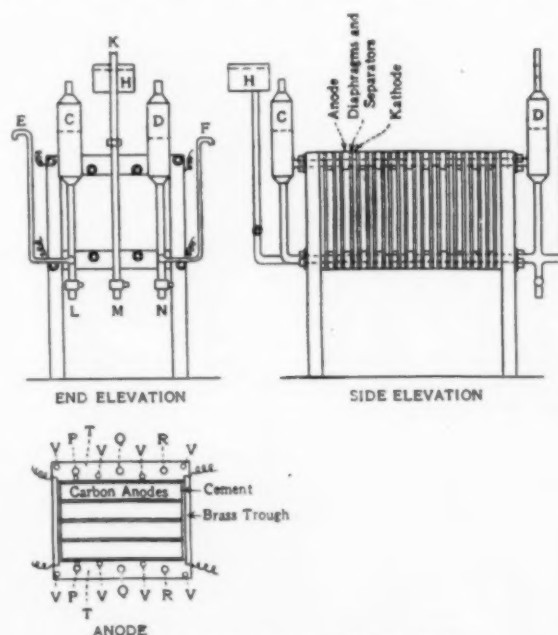


FIG. 1.—FINLAY ELECTROLYTIC CELL.

number of compartments (anodic, cathodic and brine) and corresponding electrodes can be bolted together. The various compartments are constructed by placing between the diaphragms thin rectangular or square frames of waxed cardboard about 2 mm to 3 mm thick. The various layers of electrolyte are therefore simply thin sheets of liquid, so that the electrical resistance per square foot of electrode surface is reduced as much as possible. The anodes consist of rods or slabs of Acheson graphite, the cathodes of sheet iron.

The counter-flow of electrolyte greatly aids in reducing the loss of efficiency caused by electrical migration of the hydroxyl

ions toward the anode, and by diffusion and convection of dissolved chlorine to the cathode.

The experiments described in the paper were carried out with small laboratory models suitable for 10 amp to 20 amp, and had as their object the determination of the current efficiencies and energy efficiencies of the cell. For this purpose the asbestos diaphragms sold for electrolytic purposes by Bernfeld, of Leipzig, were employed. It was found that these



S = Separator, A = Anode, D = Diaphragm, F = Frame.

FIG. 2.—HORIZONTAL SECTION.

diaphragms could be used continuously for a month without suffering any serious damage. Purified brine of density 1.18 (about 4.45 normal) was employed in the experiments.

The following table of figures gives an idea of the average results obtained, using as cathode diaphragm a 2-mm asbestos board, slightly loaded with ferric hydroxide, and as anode diaphragm a 2-mm (untreated) asbestos diaphragm.
Brine (density = 1.18). Temperature, 17° -- 19°. Current density = 0.0217 amp/sq. cm. Average voltage = 3.37.

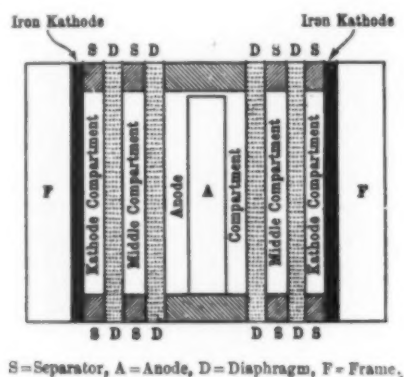| Grms. NaOH per 100 grms. cathode liquor. | Amp-hour efficiency. | Watt-hour efficiency. | Grms. NaOH per kilowatt-hour. |
|---|---|---|---|
| 4 | 98.0% | 66.9% | 434 |
| 5 | 96.5% | 65.9% | 428 |
| 6 | 94.5% | 64.5% | 419 |
| 7 | 93.0% | 63.5% | 412 |
| 8 | 91.0% | 62.1% | 403 |
| 9 | 89.0% | 60.7% | 394 |
| 10 | 87.5% | 59.7% | 388 |
| 11 | 86.5% | 59.0% | 383 |
| 12 | 83.5% | 57.0% | 370 |
| 13 | 81.5% | 55.6% | 361 |

As regards anodic efficiencies, it was found that when making 7 per cent caustic the anode gases contained 98.4 per cent chlorine, when making 13.6 per cent caustic, 94 per cent chlorine. It should be remarked that all the above figures were obtained
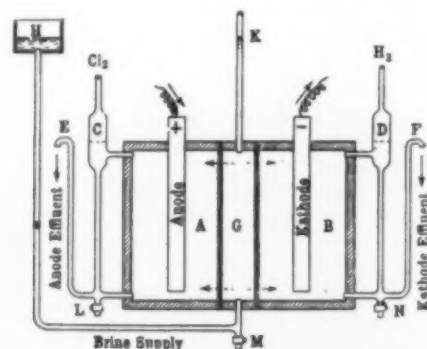


FIG. 3.—PRINCIPLE OF FINLAY CELL.

with anodes of dense amorphous carbon, as at the time of the laboratory tests anodes of Acheson graphite were unfortunately not available.

The experiments show that it is possible with the Finlay cell to make very much stronger alkali at much higher current- and energy-efficiencies than in single-diaphragm cells with non-percolating electrolyte. So far as published data go, the

results obtained with the Finlay cell appear to be superior to those obtained with the Aussig "bell jar" process, especially with regard to energy-efficiency.

Mr. ROBERT FINLAY explained that certain disadvantages inherent in the small cell tested by the authors were eliminated in the large units. He believes that in its latest form the cell left little room for further improvement. Solutions containing 8 grms. caustic soda per 100 cc could now be made at a voltage of 3 from brine at ordinary temperatures, and with a current efficiency of 98 per cent, a yield of 40 per cent higher than that of the most successful electrolytic process now worked in England. One of the chief features of the cell was the absence of secondary reactions.

## The Laws of Heat-Transmission in Steam Boilers.

On Jan. 14 Dr. J. T. NICOLSON delivered a suggestive lecture before the (British) Junior Institution of Engineers, of which he had been elected an honorary member. In his address, which we reproduce in abstract from the London *Electrical Review* of May 7, he gave the results of experiments which he had carried out at Manchester during the past four years, with a view to ascertaining the facts regarding the transmission of heat from the flue gases to the water in steam boilers.

The subject has been attacked as long ago as 1874 by Prof. Osborne Reynolds, who laid down the principle that the heat transferred is nearly proportional to the speed of flow; in 1897 Mr. T. E. Stanton confirmed the truth of this law for cases in which water only was employed, and in 1899 Prof. John Perry, in his book on the "Steam Engine," remarked that an immense increase in the rate of evaporation ought to be obtainable when a good scrubbing action was established on both sides of the metal. The Geological Survey of the United States took up the matter on the strength of Professor Perry's remarks, and further verified the law.

Introducing the subject of his own tests, the author recalls that the ordinary formula for heat flow across a plate is

$q = k (T - t)/e$ British thermal units per hour per sq. ft. where $T$ and $t$ are the temperatures (Fahr.) of the two surfaces, $e$ is the thickness of the plate in inches, and $k$ is the thermal conductivity (= 450 for wrought iron or mild steel). But this formula gives results some 200 times as great as are realized in practice.

The formula of Rankine and Peclet, $Q = (T - t)^2/a$, for the transfer of heat from the gases at temperature $T$ to the water at $t$, when combined with the foregoing, shows that the temperature of the two sides of the plate can differ by only 7 deg. or 8 deg. Fahr., most of the drop (about 1,140 deg.) taking place between the hot gases and the plate. The constant $a$ is usually taken as 200.

The author believes that there is an exceedingly thin stationary film of gas on the one side, and of water on the other, which oppose very great resistance to the flow of heat; thus, the use of copper instead of steel, or thin tubes instead of thick, in the hope of obtaining a better heat transmission, is futile.

By increasing the speed of the gases, however, to 10 or even 50 times that which now obtains, the cooled films adhering to the surface of the plate are torn off and whirled into the body of hot gases, while new films take their places. The communication of heat from a film to the plate is practically instantaneous and if the cooled films can thus be rapidly replaced, the rate of transfer of heat from the gases to the plate can be enormously accelerated.

An evaporation of 45 lb. per square foot per hour has been secured by the author, by simply increasing the rate of flow of the gases through the flue of a Cornish boiler, beyond the bridge; this was effected by nearly filling up the flue with an internal cylindrical water vessel of boiler plate, leaving only an annular space 1 in. wide, 40 in. in diameter, and 10 ft. long. The heat transmitted through the plates was 34,450 b.t.u. per

square foot per hour, about eight times the rate usually obtained, the speed of the gas current being about 330 ft. per second.

This experiment shows that the rate of heat transference is directly proportional to the speed of flow of the gas, and as Rankine and Peclet's formula takes no account of the speed, it obviously breaks down.

The power required to drive the exhausting fan amounted to about 4¼ per cent of the whole power available; on the other hand, the output of the boiler was increased to eight times the normal, and there would be therefore a great saving in the cost of boilers, floor space, etc., for equal output.

In 1905 Dr. Nicolson conducted a series of experiments on the flow of heat from warm compressed air to water both flowing in concentric pipes; these were described in the lecture in detail, and the problem of steady flow of heat under these conditions was mathematically analyzed. Other experiments of his own and other investigators were also discussed at length and a general formula was arrived at for the heat transference from a gas flowing along a flue, as follows:

$$Q = \left[ \frac{\phi}{200} + \frac{1}{40} \sqrt{\phi} \left(1 + \frac{1}{m}\right) \rho u \right] (T - \theta)$$

where

$Q$ = b.t.u. transferred per hour per sq. ft. of flue surfaces.
$T$ = temperature of gas flowing along the flue (deg. Fahr.).
$\theta$ = temperature of metal wall of flue.
$\phi = \frac{1}{2}(T + \theta)$ = mean film temperature.
$\rho$ = density of gas, lb. per cu. ft.
$u$ = speed of gas, ft. per second.
$m$ = hydraulic mean depth of flue or pipe = $a/c$.
$w$ = lb. of gas flowing per second.
$a$ = area of flue in sq. in.
$c$ = perimeter of flue in inches.
$\rho u = w/a$.

This formula was also applied to actual data and shown to give results in good agreement with those obtained in practice and it was shown how the old Rankine formula gave approximate agreement with results over customary ranges of temperature and at ordinary speeds of flow, the constant $a$ being arbitrarily modified by the users to suit circumstances.

As increased draught was ordinarily accompanied not only by higher speeds of flow, but also by a greater rate of combustion of fuel, users of the old formula accounted for the enhanced rate of evaporation per foot of heating surface, on the ground that the gas was at a higher temperature. As a matter of fact, the increased rate was due almost entirely to the higher gas speed, and only in a minor degree to the higher temperature. By the exercise of taste in the choice of the constant, the old formula was capable, by good luck rather than by intelligent guidance, of representing the results of boiler trials to a fair degree of approximation. The old formula is, however, essentially erroneous, while the new formula, being a true law of nature, holds both under ordinary conditions and under extreme circumstances.

As regards the bearing of his results upon boiler practice, the author stated that a reduction of the heating surface to even one-tenth of that now usual can be made, without increasing the chimney temperature or lowering the efficiency. Or if the surface is unchanged, but the cross-sectional area through the flues reduced, a much lower chimney temperature and higher efficiency can be secured. Draughts of 10 in. or 20 in. of water gage, induced by fans, should always be employed for economical working.

If the boiler is designed on the economizer principle, with strict attention to counter-currents, methods of flow, a chimney temeperature of 100 to 150 deg. Fahr. can be attained, corresponding to a boiler efficiency of over 95 per cent. Thus the margin of additional evaporation more than covers the power required for the fan, and therefore higher economies are attainable, with smaller boilers, less floor space and lower first cost than at present.

Combustion can be carried on in a lined chamber, ensuring perfect smokelessness. The author believes that the proposed new method of working is capable of effecting radical improvement in steam-boiler practice, without which the steam engine cannot retain its pre-eminence in the economical production of power.

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# Niagara Falls Meeting of the American Electrochemical Society.

The fifteenth general meeting of the American Electrochemical Society, held in Niagara Falls, Canada, from May 6 to 8, turned out an immense success in every respect. The whole program had been arranged with skill and foresight by the officers of the society and by the local committee.

The official Entertainment Committee, the unofficial Section Q, and all the individual Niagara Falls members rivalled each other in their efforts to make everybody feel at home. With equal courtesy the large party of visiting ladies were entertained by the ladies' committee at a reception tendered by Mrs. Acheson, and on several excursions.

The number of members and guests registered was 323, of which 187 were members and 136 guests.

At the business meeting held on May 7 the annual reports of the officers were presented, which show the society to be in a very flourishing condition with respect to membership and finances.

The result of the election of officers for the next year was announced as follows: Dr. Leo H. Baekeland was elected president to succeed Dr. Acheson, who now becomes the junior past president. Dr. J. W. Richards and Mr. P. G. Salom were re-elected vice-president and treasurer respectively. Messrs. F. J. Tone, Carl Hering and W. D. Bancroft were elected vice-presidents for two years; Messrs. E. R. Taylor, W. L. Miller and W. H. Walker managers for three years.

The new president, Dr. Leo Hendrik Baekeland, is Flemish by birth. He was formerly associate professor of chemistry at the University of Ghent and professor at the Higher Normal School of Bruges. He has been a resident of this country for twenty years and is widely known through his original chemical research work, his invention of velox paper and the so-called gaslight printing papers used in photography, his improvements of the Townsend cell for electrolytic production of caustic and chlorine, and his invention of bakelite. He also published some philosophical essays and a book on travel. His research laboratory is situated on his property, "Snug Rock," in the wooded outskirts of Yonkers, N. Y., overlooking the Hudson.

The program of papers was excellent and filled four long sessions on Thursday morning and afternoon, Friday morning and Saturday morning.

On Friday afternoon visits were paid to the various power companies on the Canadian side. On Saturday afternoon a most interesting visit was made to the works of the Development & Funding Company, where the Townsend cell for the electrolytic production of caustic soda and chlorine is in operation, and to the plant of the International Acheson Graphite Company. Since the latter plant was described in our last issue, page 187, and the former in our Vol. V, page 209, this reference must here suffice.

On the evening of Thursday, after Dr. Acheson's presidential address, a very enjoyable smoker was held, which was followed by a meeting of Section Q, with Mr. Tone in the chair, and

Messrs. Lidbury, FitzGerald, Bennie, Hooker, Cravath, Bancroft, Baekeland, and Saunders as the ringleaders. The fun began with an alphabetical roll call in form of cartoons of well-known members, thrown on the screen by lantern slides. Then followed a mock trial of a distinguished electrochemist accused of having transferred his affections to photochemistry; it ended with an acquittal. A series of short experimental lectures followed, very amusing and very clever, the program being as follows: P. McN. Bennie on the use of electrolytic

In the following we give abstracts of all the papers presented at the meeting:

### Electrometallurgy of Iron and Steel.

Practically the whole of Thursday was devoted to a symposium of papers on the electrometallurgy of iron and steel. For the success of this symposium much credit is due to Messrs. FitzGerald and Bennie, of Niagara Falls, who had been in charge of the arrangement of this special feature of the pro-



AMERICAN ELECTROCHEMICAL SOCIETY CONVENTION, NIAGARA FALLS, CANADA.

iron for the testing of abrasives; A. H. Hooker on a new method of daylight development; F. A. J. FitzGerald on the application of the ultramicroscope to electrolytic discovery; F. A. Lidbury on some electrochemical "effects." And then came more songs.

The banquet on Friday evening was a delightful affair. Dr. Bancroft was an excellent toastmaster. Dr. Acheson as retiring president and Dr. Baekeland as president-elect spoke on the work and the future of the society. Major Ernesto Stassano's toast on electrometallurgy brought out great enthusiasm. Mr. Kirchhoff spoke for the technical press, Mr. Coho on the social side of the society. Dr. Richards made announcements on the work of Sections A to Q at the meeting of the American Electrochemical Society to be held in Niagara Falls 20 years hence. Dr. Whitney spoke for the American Chemical Society, and Professor Burgess for the American Institute of Electrical Engineers. Dancing followed.

On the evening of Saturday, the Niagara Club tendered to the society an open house. This entirely informal but very enjoyable affair closed the meeting, which will always be remembered with pleasure by all who attended it and which will go down into history for the importance of the proceedings.

During the meeting a little exhibition had been arranged in the meeting hall of products of the electric furnace. Some fine exhibits of their products were made by the Electrometallurgical Company (ferro-alloys), the Carborundum Company (carborundum, silicon, etc.), the Norton Company (alundum and articles made from alundum). The FitzGerald and Bennie Laboratories had various interesting exhibits relating to the electrometallurgy of iron and steel, including photographs of the 15-ton Héroult furnace at Gary and specimens of the first electric steel rail rolled in the United States by the Maryland Steel Company, the steel being made in the Roechling-Rodenhauser furnace in Germany. Mr. John A. Yunck exhibited samples of electrolytically prepared white lead and colors. Mr. Maximilian Toch had interesting exhibits relating to the corrosion of steel. The Dossert Electrical Company, of New York, showed their connectors for making a solderless joint between the cables and the electrodes of electric furnaces (see description in our April issue, page 170). Dr. Baekeland exhibited interesting samples of bakelite, showing various electrical and electrochemical applications.

gram, and to the secretary of the society, Professor Richards, of Lehigh University.

In calling the meeting to order, the president, Dr. Acheson, called attention to the distinctly international flavor of the occasion. For the first time the society met on Canadian soil and electrometallurgical engineers from all countries had prepared papers for the meeting.

In behalf of the Canadian Government Dr. Eugene Haanel, director of mines, of Ottawa, Canada, welcomed the society in



EUGENE HAANEL.

a little felicitous speech. It is unnecessary to mention in this journal the prominent part which Dr. Haanel has taken in the advance of the electrometallurgy of iron and steel by his official reports on this subject (see our Vol. II, pages 475 and 479, and Vol. IV, page 865). It was thus but natural that Dr. Haanel should follow up his speech of welcome by presenting the first paper, in which he gave an account of his recent visit to Sweden,

where he examined a new electric furnace for iron-ore reduction.

## Electric Furnace Pig Iron in Sweden.

The furnace described in the paper of Dr. Eugene Haanel was designed by Messrs. A. Grönwall, A. Lindblad, and O. Stahlhane for the reduction of pig iron from ore. These three engineers have been carrying out an extended investigation on the electrometallurgy of iron ore for a series of years for a syndicate of Swedish iron masters and manufacturers, the Elektro-
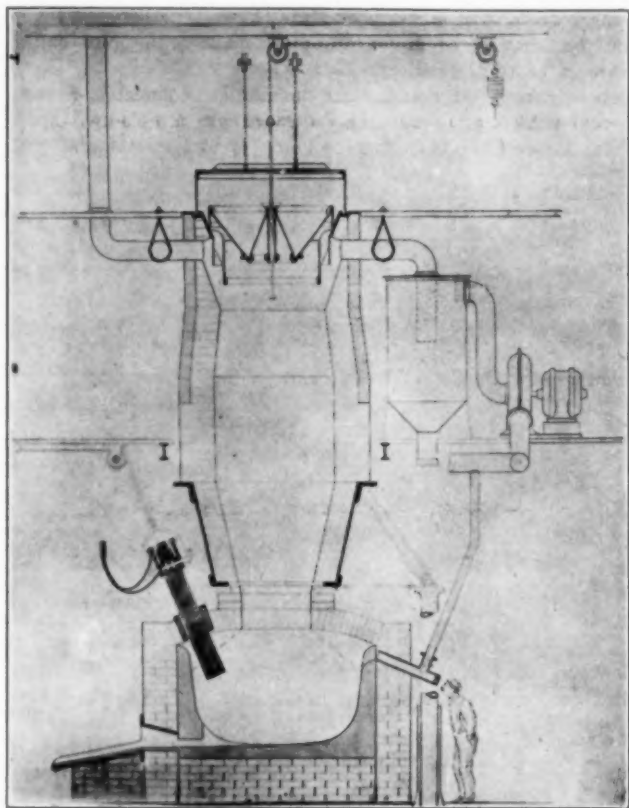


SWEDISH ELECTRIC PIG IRON FURNACE.

metall Company, of Ludwika, Sweden, having been formed for this purpose. These three engineers concentrated their attention to the construction of a suitable furnace.

Dr. Haanel first gave an account of the former experiments made under his supervision at Sault Ste. Marie with a Héroult furnace for pig-iron reduction, and of the recommendations which he had made at the end of his official report (see our Vol. IV, page 265). These recommendations have now been made use of in the design of the Swedish furnace of Grönwall, Lindblad, and Stahlbane.

This furnace is shown in the adjoining diagram. It is really a combination blast-furnace and electric-furnace design. A vertical shaft is superimposed upon and opening into a large smelting chamber at the bottom. The latter has the form of a large crucible with an arched roof. The three electrodes supplied with three-phase currents are suspended into this lower chamber; one of the electrodes is shown in the illustration at the left side. The gaseous products of reaction leave the furnace at the top and are blown back through tuyeres into lower smelting chamber, the object being to cool the roof of the furnace chamber above the electrodes. This is, in fact, the chief feature of the design. There is a peep-hole through which the attendant (shown at the right-hand of the diagram) can observe the roof of the smelting chamber; if he finds that the cooling effect is not sufficient, he permits more cooling gases to be blown through the tuyeres. There is, therefore, always a free space between the charge in the hearth and the arched roof

and in this free space the gases circulate and cool the lining.

In the presence of Dr. Haanel the furnace was subjected to a 12-day run. The voltage was 37, the current 6000 amp to 7000 amp. Dr. Haanel thinks the furnace was too big for the available power.

Charcoal was used as reducing agent, the consumption being 605 lb. per long ton of pig iron.

The electrodes required no regulation, the feeding being automatic. For five consecutive days they required no attention. Their consumption was 11 lb. per long ton of pig iron.

The tests proved that there was no clogging of the charge in the contracted neck of the shaft where it goes down into the smelting chamber. Further, the free space between the charge and the arched roof of the smelting chamber was maintained open during the run. The consumption of energy was remarkably uniform. The furnace forms, therefore, an ideal load for a power plant.

Although the circulation of the gases was not started until the end of the run, the tests were sufficient to prove that the cooling of the arched roof by the gases worked satisfactorily.

As was already noticed in our April issue, this furnace will be used in a commercial electric pig-iron plant in Norway. The first installation will be built this summer, and includes two iron-ore reduction furnaces of 2500 hp each, and two steel furnaces of 600 hp each. All furnaces will be operated with two-phase current. The plant will later be enlarged by erecting four more iron-ore reduction furnaces of 2500 hp each and four steel furnaces of larger size than 600 hp. The installation will include a rolling mill.
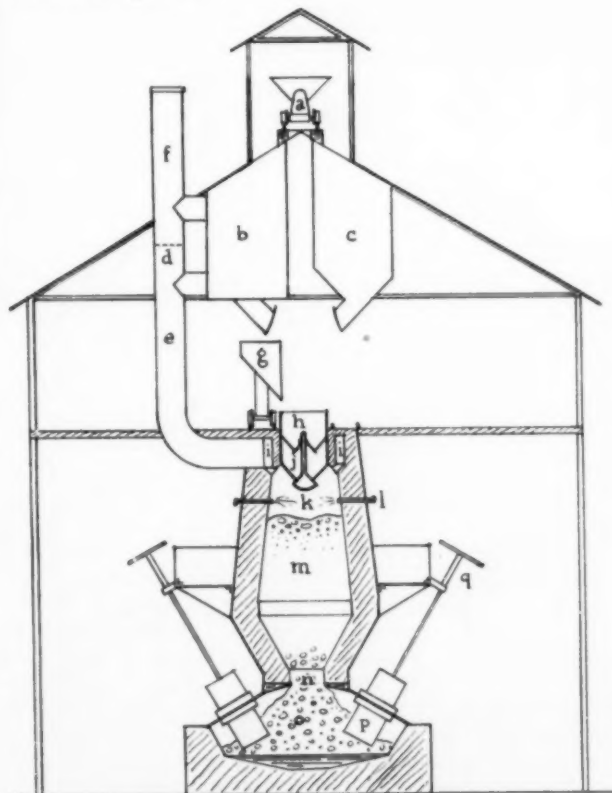


CALIFORNIA ELECTRIC PIG IRON FURNACE.

(a Supply car, b ore preheater, c charcoal bin, d bypass damper, e gas flue, f gas stack, g charging car, h upper hopper, i annular space, j lower hopper, k combustion chamber, l air inlets, m bosh and reducing stack, n contracted throat, o melting crucible, p electrode, q electrode gearing.)

## Electric-Furnace Pig Iron in California.

Mr. P. McN. BENNIE (FitzGerald & Bennie Laboratories, Niagara Falls, N. Y.) followed Dr. Haanel with an account of what has been done in the United States in attempts to create an electric pig iron industry. He first sketched the

peculiar local conditions in California, which he has studied carefully during a recent trip to the Pacific Coast and which appear to make such an attempt feasible.

Conditions at some Pacific points are peculiarily favorable to electric furnace treatment of iron ore. The present market there is not less than 150 tons a day, the supply being imported or brought a long distance by rail. Some foundries even go to the extent of melting promiscuous scrap in cupolas. Pig iron brings $9 to $10 the ton above Pittsburg base, market quotations varying from $23 to $26 the ton, whether of domestic or foreign origin.

Conditions are not favorable to the operation of a blast furnace to fill this demand. While iron ores might be had at reasonable rates the carbon problem is serious. The only plentiful fuel is California asphaltic petroleum, which cannot be used for the purpose. Metallurgical coke brought from the East by rail would be out of the question, while imported coke is not only high in price but irregular as to supply and therefore variable in price. The California demand for coke is met by importation in cargo from Germany, Belgium, and Australia. The coke is bid for upon arrival, hence the irregularity both as to price and supply. The price may be anywhere between $10 and $13 the ton. Therefore a blast furnace plant would be an investment of uncertain value.

With electric smelting of iron ores the cost of carbon becomes of less importance, the quantity used being only about one-third that required for the blast furnace. Further charcoal can be used. If it is possible to assemble cheaply iron ore, limestone and electric power at one place, we could afford to use coke or charcoal at a price prohibitive so far as a blast furnace is concerned.

Such conditions may be found in several places in California within easy reach of the principal market. One such location has been chosen for exploitation by the Noble Electric Steel Company.

The equipment of the Noble Steel Company's plant is described in the paper (reported below) by Professor Lyon. In supplementing this paper Mr. Bennie stated that the experimental 160-kw furnace was run for a period of about 40 days, during which time data were gathered to be used in the design of the present 1500-kw furnace. The results thus experimentally obtained make it not unreasonable to expect a power consumption around 0.25 hp-year per ton. Without allowing anything for by-products, charcoal will probably cost $9 a ton, of which one ton should be sufficient for about three tons of pig iron.

If the figures obtained with the smaller furnace can be realized in the 1500-kw furnace, the cost of pig iron should be in the neighborhood of $15. The freight to San Francisco should not exceed $3 per ton. Now when it is considered that the product will be charcoal pig iron, and should command a higher price than ordinary blast furnace pig iron, there seems to be a comfortable margin of profit for the manufacturer.

Another point not touched by Professor Lyon is that such high-grade pig iron, coming from the electric furnace in a molten state, would be most desirable starting material for steel. The liquid metal could be tapped into a second electric furnace and refined to steel, particularly in view of the very pure iron ore available, or a modified method like the Lash process could be used. The added expense would be less than the added value, so there would be a distinct gain for the manufacturer.

## Noble Steel Co. Works in California.

Prof. Dorsey A. Lyon, general manager of the Noble Steel Company at Héroult-on-the-Pitt, Shasta County, Cal., contributed a paper on the equipment of this pioneer electric pig-iron plant of this country. For 25 years or more a company known as the Shasta Iron Company has owned a deposit of magnetite, located about seven miles from the mouth of the Pitt River, in Shasta County, Cal. The ore is a very pure magnetite,

containing 69.9 per cent iron, and having on the average the following composition: 89.4 $Fe_3O_4$, 7.3 $Fe_2O_3$, 0.10 MgO, 0.18 MnO, 2.40 $SiO_2$, 0.011 P, 0.009 S. It occurs at the contact between limestone and diorite and the ore body is remarkably uniform.

The limestone is also of excellent quality, with an average composition of 1.2 per cent $SiO_2$, 0.5 $Al_2O_3$, 1.1 MgO, 53.8 CaO, 0.2 FeO, equivalent to about 98 per cent calcium carbonate.

In 1907 the possibilities of these deposits were brought to the attention of Mr. H. H. Noble, president of the Northern California Power Company, which practically supplies all the electric power for mines and smelting in Shasta County. After some correspondence with Dr. Paul Héroult, plans were made for the erection of an experimental plant at a point called Héroult, on the Pitt River.

In July, 1907, the first furnace having been completed, experimental work was begun. This furnace was a 1500-kw, three-phase furnace of the resistance type. It was soon found that



PLANT OF NOBLE ELECTRIC STEEL CO., HEROULT-ON-THE-PITT, SHASTA CO., CAL.

the type of furnace first used presented mechanical difficulties which made its commercial use impractical, and so it was closed down. Since that time the experimental work has been carried on in a 160-kw furnace, and from the results obtained in this furnace, and its method of operation, another 1500-kw furnace was designed and built, which, at this time, would probably be in operation but for the heavy storms of January and February, which caused practically a cessation of construction work during that time.

At present the iron ore is mined by quarrying. From the mine the ore is to be taken to the smelter by means of a surface and gravity tramway. The distance from the mine to the top of the gravity is about 6000 ft.

The furnace design is shown in the illustration on page 251.

Above the crucible at the base of the furnace is a superposed stack which resembles an ordinary blast furnace and which has a bosh communicating with the crucible.

In the operation of the furnace, the ore, mixed with its proper proportion of fluxing materials will be fed unto a preheater (b) wherein it is to be dried and heated. The source of the heat for the preheater is to be derived from the products of combustion from the combustion chamber (k) at the top of the stack, which will be let into the base of the preheater through a flue (e) which communicates with an annular chamber surrounding the top of the stack and communicating with the production chamber (k) through openings or ducts (l).

A scale car (g) runs upon a circular track round the top of the stack and will alternately receive a charge of ore and flux from the preheater (b) and a weighed charge of carbon from the carbon hopper (c), these charges being delivered alternately by proper mechanism into the body of the furnace.

In the operation of the charging device a charge of ore and flux will first drop into the upper portion of the hopper, the bell (h) being closed, and after the charge is properly distributed about the hopper the bell (h) is lowered so as to per-

mit the charge to pass into the lower compartment of the hopper, the upper bell being then closed and the lower bell ($j$) opened, so as to permit the charge to pass into the stack. The charge of carbon is then fed into the furnace through the charging device in the same way.

The charge will be kept at about the level of the dotted line shown in the stack. Above the level are small openings in the stack with suitable valves for admitting the requisite amount of air to burn the gases resulting from the reduction of the ore in the lower part of the stack, thus still further heating the charge, and, as above stated, these waste gases will then pass through the preheater ($b$) thus preheating and drying the ore before it is charged into the furnace.

The electrodes, six in number, are arranged equidistantly around the furnace. The electric current passing through be-
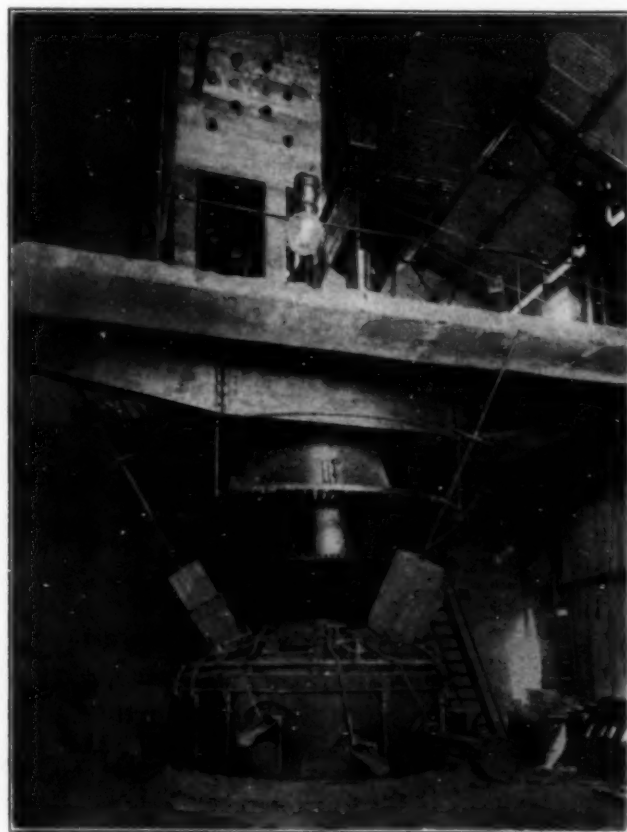


OLD ELECTRIC PIG IRON FURNACE AT NOBLE ELECTRIC STEEL WORKS.

tween them melts the charge, and the molten metal and slag are collected in the crucible, from which they are drawn as in ordinary blast-furnace work.

Charcoal is used as the reducing agent in the electric furnace plant. The description of the **charcoal plant** forms the concluding part of Professor Lyon's paper.

The retorts are cylindrical in shape and are mounted in an upright position in concrete and brick, there being four retorts to a battery. The wood is placed in cages similar in construction to the retorts themselves, and these cages are then placed in the retorts.

The volatile products obtained during the distillation of wood will be condensed by means of condensers in building and then pumped to the refining building, where the condensed vapors will be refined into commercial products.

After the distillation of the wood is complete the cage containing the charred wood is to be taken from the retort and placed in a cooling stand until its temperature has been lowered below the flashing point of the charcoal.

In the meanwhile another cage containing a charge (two

cords) is placed in the retort and the charring begins, together with the accompanying driving off of the volatile constituents. The cages in which the work is placed are air-tight, the opening for the escape of the volatile constituents being closed automatically when the cage is lifted from the retort.

When the charcoal has cooled below its flashing point, it is to be discharged into the charcoal storage bin, which is cylindrical and entirely closed except for an opening near the top just large enough to receive the bottom of the cage through which the charcoal is discharged. From the charcoal bin the charcoal is to be taken to the furnace building and hoisted to the charging floor and dumped into the charcoal hopper ($c$).

The wood is reduced to charcoal containing about 95 per cent carbon, the condensable part of the vapor being collected in tubular condensers, the uncondensable gases being led under the furnace and burned. The quality of charcoal that can be made from our wood supply is very good, the following being specimen analyses of charcoal from their ordinary bee-hive ovens:

|                            | I.   | II.  | III. |
| -------------------------- | ---- | ---- | ---- |
| Water and volatile matter..........  | 5.3  | 7.8  | 6.5  |
| Ash ................................. | 0.5  | 0.7  | 0.6  |
| Carbon ............................. | 94.2 | 91.5 | 92.9 |

It is also the intention to introduce at this plant an electrolytic method of making lead acetate, for which there is a certain demand on the Pacific Coast. The entire plant is designed to produce charcoal at low cost for labor, for the utilization of waste heat and saving of time.

### Electric Furnace Reduction of Iron Ore.

Prof. J. W. RICHARDS, of Lehigh University, compared in his paper the reduction process in the blast furnace and in the electric furnace.

An outline of the principles of blast-furnace practice is first given. Fuel is needed to provide heat and reducing effect. The heating effect is almost entirely produced by the combustion of the larger part of the fixed carbon (non-volatile carbon) of the fuel to carbon monoxide before the tuyeres. This combustion fills two functions. It provides the high temperature necessary to melt down the iron and slag, and it provides large quantities of reducing gas, practically identical in composition with producer gas (30 to 35 per cent CO, 1 to 2 per cent $H_2$, rest $N_2$), which performs in the upper part of the furnace the larger part of the reduction done in the furnace.

The amount of fuel used in a blast furnace is determined by the amount which must be burned at the tuyeres to produce the necessary smelting temperature, and not by the amount necessary to perform the reduction of the metallic oxides. The amount necessary for performing the reductions taking place in the furnace is only one-third to one-half of the amount necessary to be burned to provide the smelting heat.

The proportion of carbon ordinarily consumed at the tuyeres is 9 atoms (108 parts) of carbon for each molecule of iron oxide (160 parts) reduced by the carbon monoxide gas. The chemical equation is:

$$Fe_2O_3 + 9\,CO = 2\,Fe + 3\,CO_2 + 6\,CO.$$
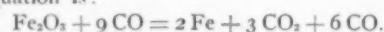
This equation shows that only one-third of the carbon monoxide produced before the tuyeres in generating the smelting temperature is utilized in reduction, while two-thirds escapes unused.

On the other hand, in the electric smelting furnace all necessary heat is supplied by electrical energy, no blast is blown in, and, therefore, all the solid carbon is utilized for reduction (always excepting the small amount which dissolves in the pig iron). In calculating the amount of carbon necessary to thus reduce the iron oxide we meet at the outset with this difficulty: What proportion of the carbon will form $CO_2$ and what proportion CO? We know that when reduction takes place at a very high temperature, CO is almost the only product; but as this passes more or less slowly through the cooler

portions of unreduced charge $CO_2$ is formed in increasing amounts until at a low red heat, given sufficient time, about half the CO may be converted into $CO_2$. The formulas corresponding to these two extremes are:

$$Fe_2O_3 + 3C = Fe_2 + 3CO.$$
$$Fe_2O_3 + 2C = Fe_2 + CO + CO_2.$$
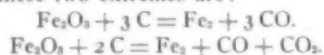
Comparing this with the ordinary blast furnace, which requires 9 C put into the furnace for the reduction of $Fe_2O_3$, we see that 3 C, or one-third, as much carbon is the greatest amount necessary in the electric furnace reduction, and 2 C or between one-third and one-fifth as much, is the smallest amount necessary. Further, the uncertainty as to how much $CO_2$ can be formed in the electric furnace reduction is perhaps the chief difficulty in running the electric furnace.

A numerical example is then given and finally it is emphasized that the electrical reduction of iron ore differs radically from blast-furnace practice in one essential particular, viz., that since no air is blown in, any excess of carbon above that consumed in reduction must remain unused, accumulate and eventually clog the furnace. The amount to be used as a minimum cannot, moreover, be calculated until we know how much $CO_2$ will be formed in reduction, and that is an unknown quantity unless arrangements are made so that none can be formed.

A number of interesting suggestions are then made on a possible combination of blast and electric furnace with the object in view of avoiding the accumulation of excess carbon in the furnace. The best solution of this difficulty, in Dr. Richards' opinion, is to provide tuyeres by which air can be sent into the crucible of the furnace, and thus burn any accumulation of carbon. A given quantity of air will always burn a given quantity of carbon, and therefore the cure would seem to lie in having a variable supply of air, which is increased whenever the falling resistance of the furnace indicates that carbon is beginning to accumulate, and diminished to a small minimum supply, only enough to keep the tuyeres open when the furnace is in good electrical running order. It would represent a combined electrical and blast furnace, with the blast so regulated as to overcome the chief difficulty of the purely electrical furnace—the accumulation of unused carbon in the crucible.

It may be quite possible, by some such device as Mr. Taylor's large electrical furnace, to practically combine the blast furnace and the electrical furnace. Dr. Richards is "quite confident that any practicable method of introducing electrical heat into the crucible of a blast furnace will result in large economies in the furnace working. Only one-quarter of the heating power of the fuel is developed around the blast tuyeres, and yet if half of this could be replaced by electrically generated heat an economy of 50 per cent could in all probability be reached upon the fuel bill. To put it into figures, it takes 1.2 tons of coke to make a ton of pig iron in the blast furnace and about three-quarters of a ton is burned by the blast producing at the smelting zone, about 25 per cent of the calorific power of the coke. If electrical energy could be made to supply only one-half of this, the furnace would make iron with half the previous coke supply, that is, with 0.6 ton of coke per ton of pig iron, and this with an expenditure of electrical energy equal only to 12.5 per cent of the calorific power of the coke, that is, equal to the calorific power of but 0.15 ton of coke.

"The question of economy in this case will not be, then, the simple replacement of fuel heat energy by an equivalent amount of electrical heat energy, but the comparison of fuel-heat energy with the cost of one-fourth its amount of electrical heat energy. This may be quite possible in many localities and the combined furnace would work more regularly than a purely electrical furnace. The question awaits the coming of the electrometallurgical engineer who can make practicable the requisite combination. A possible solution may be to use cheap electrical power to superheat the hot blast, and thus to make

the blast itself the agent for carrying electrically developed heat into the furnace."

### Discussion.

The four papers of Haanel, Bennie, Lyon, and Richards all referring to pig-iron reduction in the electric furnace, were discussed together.

Dr. Haanel referred to the attempt made at the Noble Steel Company's plant to burn the carbon monoxide gases in the top of the shaft to carbon dioxide for preheating the charge. The same attempt had been made in the Soo experiments, but it had been found that this caused the charge to stick and clog, and much labor was required to poke and feed the charge downward.

Mr. Bennie replied that no trouble of this kind was experienced at the Noble plant. Their charge does not fill the whole shaft to the top and the carbon monoxide is burned in the space above the charge. The preheated charge moves freely downward without extra help.

Dr. Richards referred to the absence of nitrogen in electric furnace pig iron as compared with blast-furnace pig iron. This may make electric furnace pig iron specially suitable for steel making. At least this should be investigated by tests.

Dr. Moldenke said the presence of oxygen causes more trouble than nitrogen. It is of decisive importance whether pig iron is good or poor. The content of oxygen in electric pig iron should be tested.

Mr. Bennie said that at the Soo and in California considerable difficulty had been experienced with the slag. Under the highly reducing conditions a lot of silica is reduced. The silicon goes into the iron. The slag is sticky. The best way is not to add any silica.

This finished the discussion of the making of pig iron in the electric furnace. All the following papers referred to the use of the electric furnace for making and refining steel.

### Stassano Steel Furnace.

The first paper on electric steel furnaces was from the distinguished Italian electrometallurgist, Major ERNESTO STASSANO, who was himself present. His paper was read in abstract by



ERNESTO STASSANO.

Prof. J. W. Richards. Since we published an exhaustive article by Major Stassano on his furnace in our August issue of last year (Vol. VI, page 315), a concise summary of his present paper must suffice here.

Major Stassano first made some remarks on the strong competition which now exists between different electric furnace designers and engineers; this is but natural and is justified "to a certain point." A review was then given of the evolution of the design of arc, resistance and induction furnaces. The principles are not new. Nor is there any new mysterious force or power

brought into the metallurgy of iron and steel. In all the different types of electric furnaces for iron and steel the electrical energy has no other function but to be transformed into heat.

The Stassano furnace is a rotary-arc furnace, heating the charge by radiation from above. It is a hermetically closed apparatus, thus ensuring a perfectly neutral atmosphere. The heat of the arc and the closed apparatus make it possible to get the highest temperature. Further, the entrance of any foreign substances is perfectly eliminated. It is quite possible to work always with a full charge.

In the tightly closed Stassano furnace, the electric arc operates like an "enclosed arc" of great length and burning very
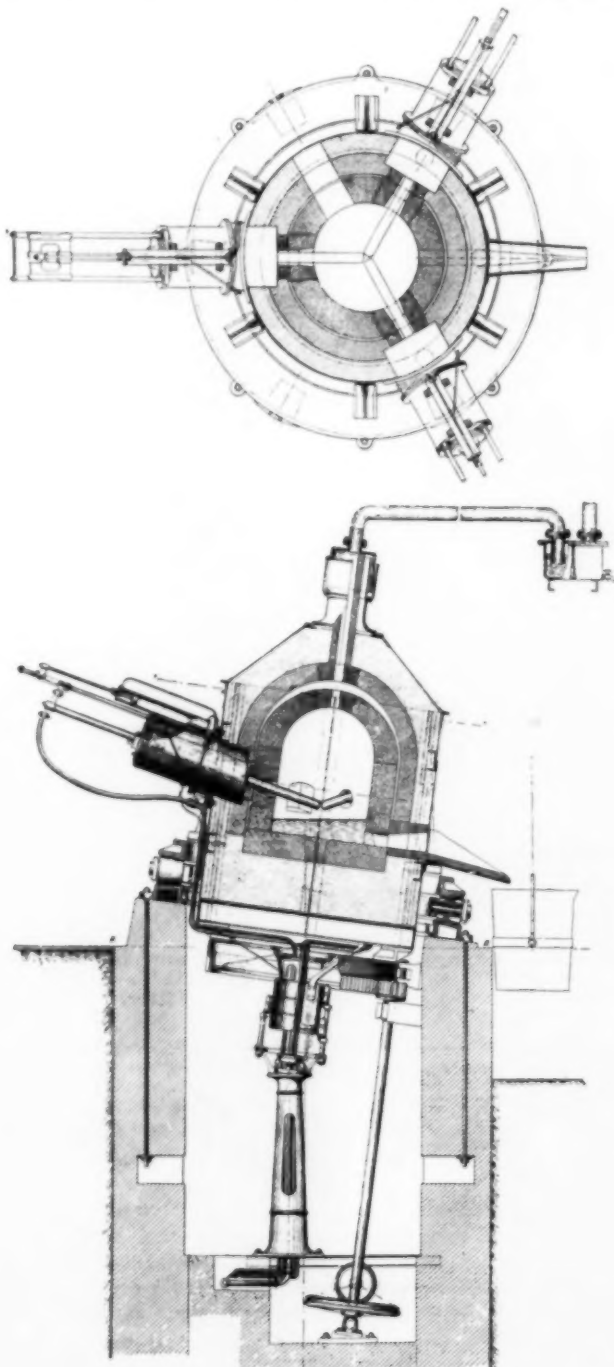




SECTIONS STASSANO FURNACE.

quietly. Mr. Stassano thinks that in furnaces of the type having two arcs in series, each arc playing between electrode and slag, some entrance of air cannot be avoided. He also claims that the induction furnace has a slightly oxidizing atmosphere.

As to the requirement that the charge should not get into contact with any foreign substance, he thinks that this is fulfilled only in the Stassano furnace and the induction furnace.

Mr. Stassano replied at some length to the criticisms which have been raised against his furnaces as being complicated on account of the mechanism for rotation. "A locomotive has many parts, but it works perfectly well." So does his furnace.

There is no real complication in the mechanism. As an experience of many years, Mr. Stassano stated, that the operation of his furnace was perfectly reliable and free from troubles. He considers a high density in electrodes as economical.

The rotation of the furnace is only an apparent complication. The charge has a natural automatic agitation, but the rotation of the furnace helps further in producing an absolutely uniform and homogenous metal.

Little heat is lost by radiation. As a matter of fact, the outside of the furnace is cold.

Mr. Stassano gave two specific examples of the application of his furnace to steel making. Several tables of this kind were given on pages 316 and 318 of our Vol. VI.

At the conclusion of his paper a diagram was given of the fluctuation of power during a whole day's run of the Stassano furnace. It showed a very great regularity of power consumption.

### Keller Electric Steel Process.

Quite an extensive paper was contributed by Mr. CHARLES ALBERT KELLER, managing director of the Société des Etablissements Keller-Leleux, Livet Works, Isere, France. In the first



C. A. KELLER.

part of his paper he described a **conducting non-carbon hearth.**

Conducting hearths, made of carbon, are nothing new in electric-furnace practice. But for steel smelting or refining it is essential to avoid carbon, so as not to change the carbon content of the steel.

However, non-carbonizing conducting hearths have also been known for a long time. They may be constructed in various ways. The entire furnace bottom may be made of metal and water-cooled, but this construction is practically impossible, as it is not durable and represents a constant source of danger.

Another construction is to use one or more metallic poles, embedded in non-conducting masonry. Siemens' historical furnace (1880), a furnace of Borchers and various constructions of Girod belong to this general type.

Another method is to make a uniformly conducting hearth by use of a rammed conducting lining, as has been done by the Firming Steel Works (French patent, 387,747, March 4, 1908). Here the hearth is formed of a refractory mixture rendered conducting by the introduction of carbon, or carboniferous mate-

rial (tar-pitch), into the refractory material (magnesia, silica, etc.).

The carbon content of the material is progressively raised at different levels in the depth of the hearth, so as to utilize at the beginning of a run the variations in electrical conductivity of the rammed mixture, according to their content of carbon material. The upper layer of the lining mixture which comes into contact with the steel is formed of a mixture quite low in carbon, so as not to influence the carbon content of the steel.

According to the inventors, the crucible having once been heated becomes permanently conducting, no matter what the variations of temperature of the furnace; consequently restarting from the cold state becomes practically possible. The

very easy, because it is uniformly conducting throughout its entire transverse section, by reason of the iron bars near together.

The mechanical resistance of the hearth to penetration by the bath is very considerable, and no deterioration by lifting of the bottom, splits or fissures is to be feared. Finally, the mechanical joining of the bars at their lower ends, and their intimate union by the pisé make the bottom block of the furnace absolutely undeformable.

This conducting hearth block constitutes the original portion of the furnace, of which the working chamber is formed as ordinarily by a metallic structure lined with basic refractories strongly fastened and braced. The chamber is enlarged above
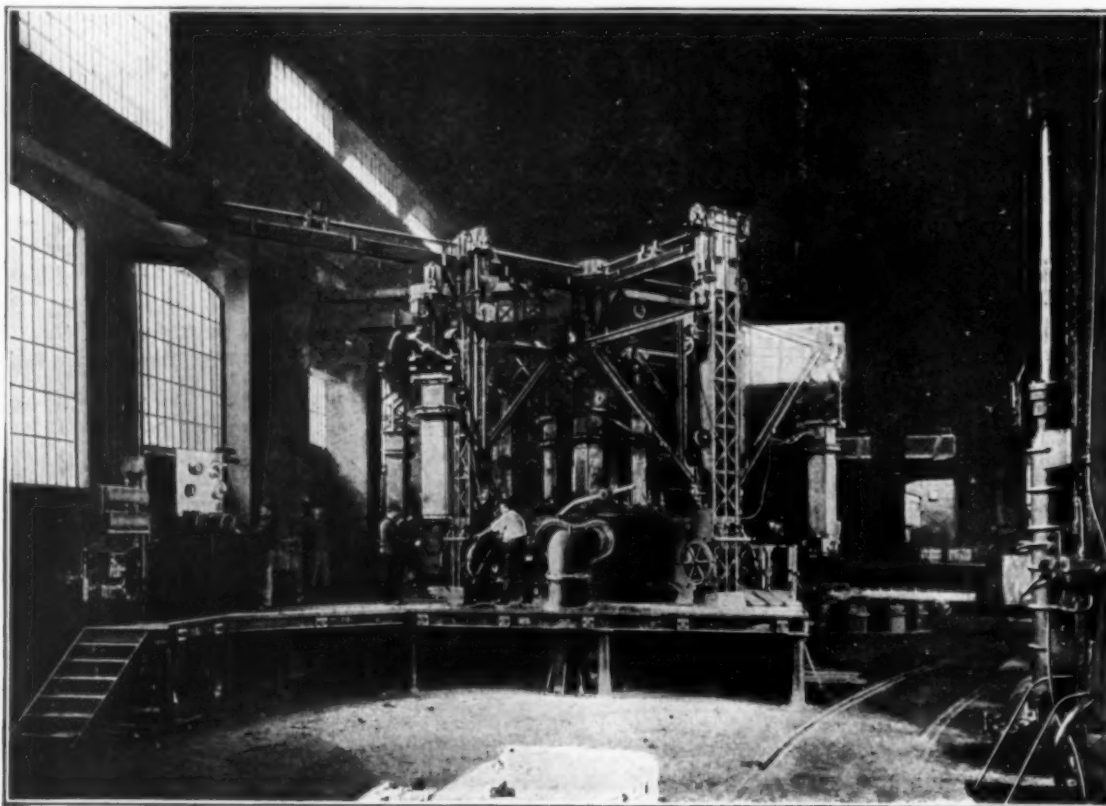


KELLER FURNACE PLANT.

Firming Steel Works, where this furnace was invented, have, however, constructed up to the present time only one furnace of small capacity.

Mr. Keller then describes his own bottom construction, which he characterizes as a "compound conducting hearth." This requires no masonry whatever.

The conducting hearth is composed of electrically reinforced pisé (pisé armé) made as follows:

Iron bars 1 in. to $1\frac{1}{4}$ in. diameter, regularly spaced about 1 in. to $1\frac{1}{4}$ in. apart, are placed vertically and made firm to a metallic plate at the bottom, so as to form a group completely filling the furnace bottom, upon which will rest the liquid metal. A pisé consisting of magnesia is strongly rammed while hot between each group of four adjacent bars, which thus form by reason of their mechanical strength, a sort of mold, permitting considerable compression of the mixture introduced. The pisé thus formed must be driven home by means of a suitable rammer.

In this compact mass or block the metallic sections are good conductors when cold; when heated, the pisé also becomes rapidly conducting. The whole is surrounded by a metallic casing cooled by a current of water. The lower plate fastened to these iron bars is connected to one of the poles of the source of electric supply.

This conducting hearth makes the starting up of the furnace

the hearth for better support of the hearth block. The pisé is easily repaired through the charging doors, after tapping, when necessary.

The body of the furnace is cooled on its entire periphery at the upper level of the hearth, to insure protection at the junction of the lining of the working chamber with the hearth.

The furnace is closed by a cover, through which the electrode passes. The regulation of the electrode is accomplished either by hand or automatically; the latter is more simple and preferable.

To avoid shut-downs, when replacing an electrode, the latter is placed at the end of a swinging arm, so that it may be removed out of the way, and replaced by another electrode all ready at the end of a similar swinging arm; the changing of an electrode is thus accomplished in two to three minutes.

There may be only one electrode at the top; this is then in series with the hearth. Or there may be several electrodes at the top, all in parallel with each other and all in series with the hearth. Or there may be several electrodes at the top; for instance, three, connected to the three phases of a three-phase system, while the hearth forms the neutral point.

The hearth of a furnace of 3300-lb. capacity, especially dismantled for inspection and study, after several months' service, was in absolutely as good condition as on the first day, the

pisé having acquired an extraordinary hardness, comparable to rock, so that a drill was blunted.

\* \* \*

In the second part of his paper, Mr. Keller compared **series** and **parallel** connection of the upper electrodes. If the upper electrodes are **in series,** as in the Héroult furnace, the current passes from one electrode in form of an arc to the slag, passes through the slag, and passes again in form of an arc from the slag into the other electrode. Mr. Keller calls this "surface electric heating." If the upper electrodes are **in parallel,** the current passes in the form of an arc from them into the slag and downwards through the steel bath and leaves the furnace through the conducting hearth. Mr. Keller speaks of this system as complete "electrification of the mass of molten steel."

Mr. Keller claims the following advantages for the parallel system, especially for furnaces of low or medium capacity:

high magnetic permeability, such as wrought iron, cast iron or steel, inside the inductive loop.

However, while Mr. Keller recognizes that the electric furnace with a conducting hearth necessitates greater precautions in its practical design and construction than the furnace with electrodes in series, yet he thinks that the engineer who is thoroughly familiar with alternating currents will know how to get around and avoid the difficulties which the problem presents, and even in a furnace of very large capacity may obtain a reasonable power factor. This is more particularly true if the engineer is allowed to design the whole electro-metallurgical installation, for under such circumstances he will not fail to adopt a low-frequency (20 periods, for example), which will greatly simplify the design on account of the reduction in the inductance of the circuit.

According to Mr. Keller, with a frequency of 20 periods a 1000-kw furnace may have a power factor of 0.9 and a capacity
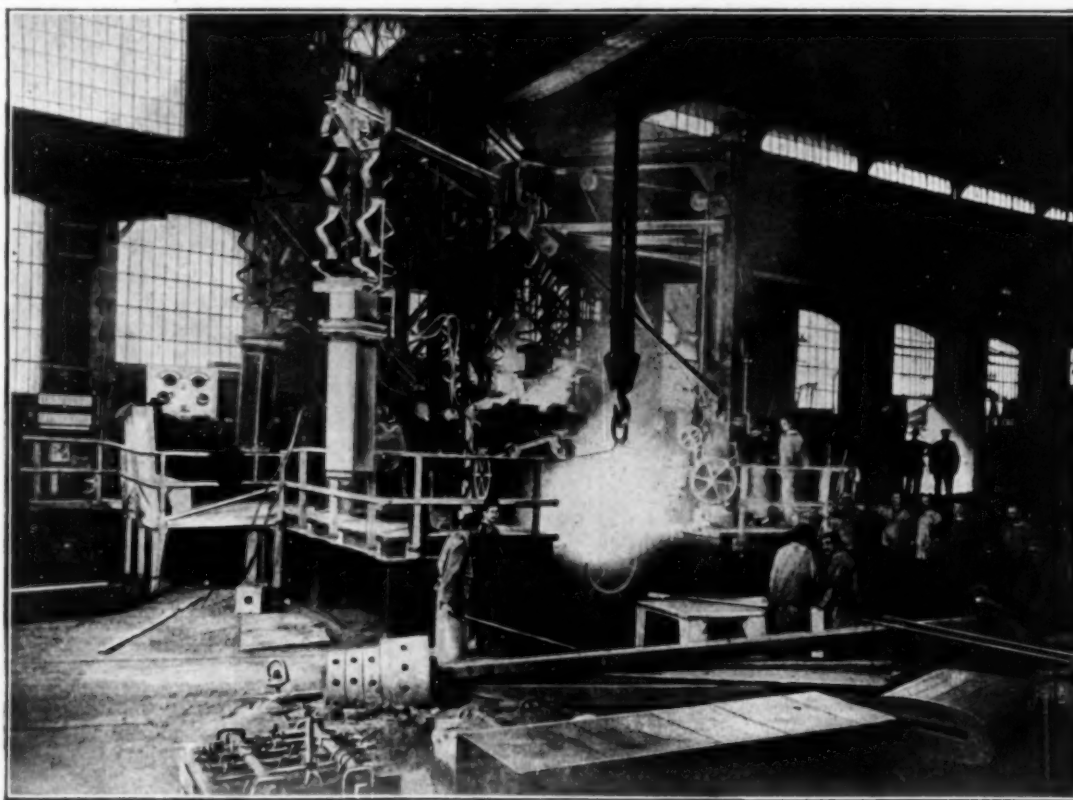


KELLER FURNACE PLANT.

Greater homogeneity of the metal produced; greater simplicity of starting and operation when used for the treatment of a cold charge; greater ease of preserving the roof of the furnace.

On the other hand, the parallel system has the following disadvantages: There are electrical fittings at the lower part of the furnace, while there are none with the series system. Further, in the furnace, with two upper electrodes in series and with an equal rate of generation of energy, the current density is only one-half that in the furnace with the conducting hearth, which means conductors of larger size for the parallel system. Further, the furnace with the conducting hearth necessitates a pretty large inductive loop, which contains the body of the furnace itself, while this is outside the magnetic field in the case of furnaces having electrodes in series. Finally, the power factor may be quite low if special precautions are not taken. It is necessary to resort to the construction of non-magnetic gaps in the furnace body, and its fittings; and in addition great care must be taken to avoid the use of fittings made of a metal of

of 10 to 12 tons for molten steel refining and finishing. He thinks the whole practical problem is the design of a durable non-carbon hearth and this, he thinks, he has solved.

\* \* \*

While Mr. Keller now appears to favor a furnace construction with parallel-connection of the upper electrodes and with the compound hearth of his own design, he has formerly used for a number of years furnaces with series connection of the upper electrodes. A summary of his experience with the series system is given in the third part of his paper.

He first gives a review of his early experiments at the Kerrousse Works (Morbihass, France). This installation was described and illustrated in an article by Ch. Bertolus and P. McN. Bennie, in our Vol. I, p. 163 (January, 1903).

Mr. Keller then experimented at the Keller-Leleux Works in Livet, Isere, with a 5500-lb. furnace with two electrodes. As the result of these experiments an 8-ton to 10-ton furnace was installed in 1905 at the Unieux Steel Works of J. Holtzer &

Company (Loire, France), the object being to finish, in an electric furnace, molten steel from an open hearth.

The electric furnace of the J. Holtzer Steel Works has four vertical movable electrodes, connected to the two poles. Each electrode forms at its base a heating zone in which the temperature can be regulated. Each pole carries two electrodes in parallel.

The movable furnace body is a self-contained crucible without any electrical connection whatever. The electrodes are suspended from rotable electrode supports in electrical connection



KELLER FURNACE PLANT.

with a central block or tablet for distribution of the current. These supports are entirely independent of the furnace body, and when they are all turned outward the cover of the furnace may be easily lifted or removed.

Then there is an overhead system of busbars for distribution of current, with fixed laterals for the movable connections to the revolving electrode brackets; and finally the switchboard for the electrodes, with suitable arrangements for control from a distance, and the measuring instruments.

Hydraulic power is used for the movement of the electrodes and the following combinations can be made:

(1) Simultaneous raising of two electrodes of the same polarity or of the four electrodes together.

(2) Simultaneous raising of two electrodes of the same polarity and simultaneous lowering of two electrodes on the other pole.

(3) Raising of one electrode and simultaneous lowering of the other electrode of same polarity.

(4) Separate movement of any electrode.

The regulation of the electric circuits is obtained very simply in the following manner:

(a) Regulation of Voltage: If there is simply an inequality of voltage between the two poles, the two electrodes on each pole are simultaneously moved up and down with respect to each other. This is done by operating valves on the hydraulic equipment.

(b) Regulation of Amperage: The amperage is equally divided between the four electrodes by means of their separate movement; if there is simply an inequality of amperage between two electrodes of the same polarity, there is a simultaneous and inverse movement of these two electrodes. Thus also by a single manœuvre the amperage is balanced between the electrodes.

It is very easy to replace an electrode. When the rotating arms carrying the electrodes are turned outwardly, the furnace body is entirely free of overhead encumbrances. The control connection block, which is placed high and out of the way, does not interfere with the lifting of the cover, the latter being rapidly done by means of the traveling crane which passes over the furnace. In this way any cover requiring repairs may be easily replaced by a spare one; furthermore, the cover being lifted, repairs to the chamber itself are very easily made.

The overhead central distributing system having radiation branches placed directly above the electrodes gives such a low self-induction that tests made at the J. Holtzer Steel Works have shown that the value of the power factor was about 0.97 with a current of 12,000 amp.

To avoid any possible chance of short-circuits between the two poles in the movement of the electrodes the following arrangement is used. Very thin flexible bars, of ½ mm thickness, for example, are attached at one end with the fixed conductors connected to the central busbar system, and with the electrode support. These flexible bars are divided into two sets expanded and brought together again at several points in their length, where they are securely fastened. There is thus formed a series of flexible rings which contract and enlarge according to the position of the electrode. Where the bars are fastened together to complete each circle, they are fitted with small rings which slide up and down on cylindrical rods, thus acting as a guide and adjusting position.

During working the gases generated in the interior of the chamber create a slight pressure; this condition is imperative to avoid all entrance of air which would destroy the reducing character of the furnace atmosphere.

At the Unieux Works of J. Holtzer Steel Company steel is made in an open hearth, poured into a ladle and then immediately fed into the electric furnace. The refining may be carried to 0.01 per cent and 0.01 per cent P; regular practice gives S and P = 0.015 to 0.02 per cent.
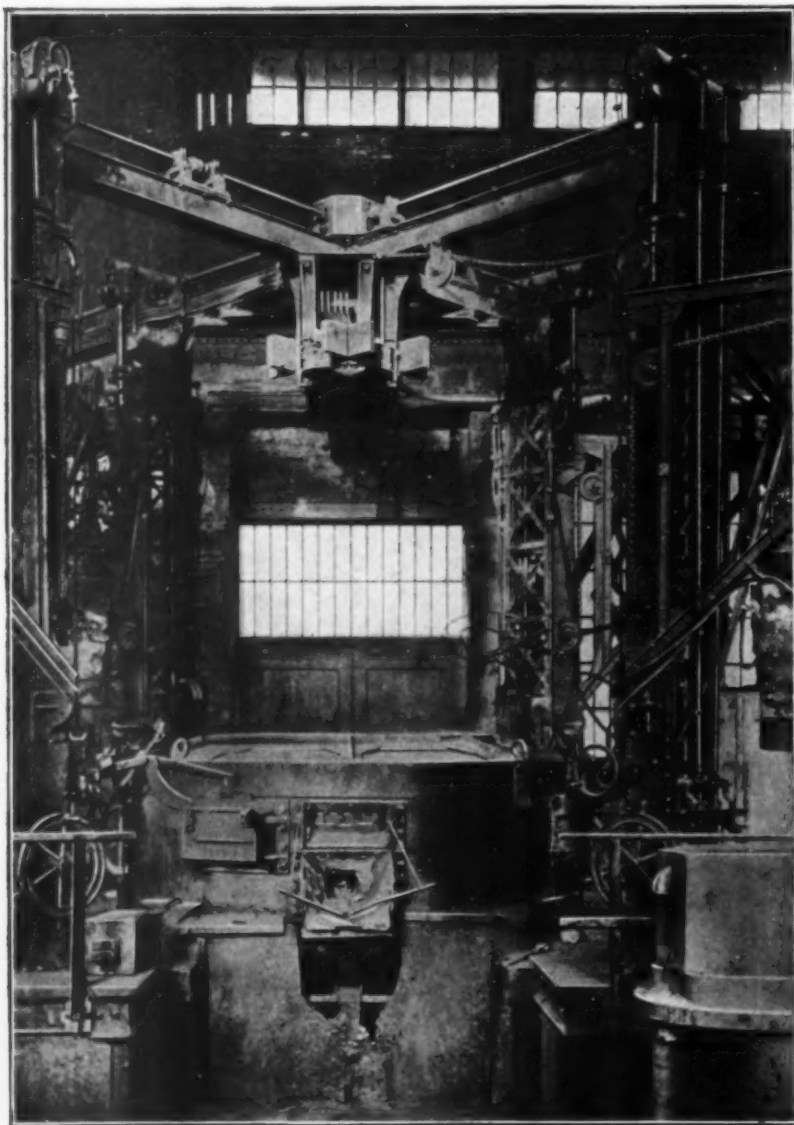
The period of treatment varies, of course, with the quality of steel desired. As an example of regular practice the following results are quoted:

Weight of charge put into electric furnace, 7500 kgs.
Mean power during operation, 750 kw.
Period of working, 2 hours 45 minutes.
Composition of molten charge:

| | | |
|---|---|---|
| C | 0.15 | per cent |
| S | 0.06 | " |
| P | 0.007 | " |

Carbon content sought, 0.45 to 0.50 per cent.

Analysis of product: C 0.443 per cent, S 0.009 per cent, P 0.008 per cent.

Energy consumed per ton, 275 kw.-hours.

Electrode consumption, 18 mm per hour for four electrodes having a cross-section of 400 mm x 400 mm.

For continuous working and assuming the cost of electrodes to be 35 francs per 100 kgs. this corresponds to a cost of about 4 francs (80 cents) per ton of steel.

The labor on the furnace, including feeding of the necessary materials, was provided by three laborers and one melter.

The regulation was manual and attended to by one of the three laborers, who looked after the repair of the furnace and the connection of the electrodes. But the regulation could be carried on just as well by automatic regulators.

Mr. Keller thinks that the electrode furnace should find its principal place in metallurgy in the direct application of three-phase currents, since many steel works already use three-phase currents for power purposes. The electrodes may be connected in delta or star. In the latter case the furnace hearth is made the neutral point. According to Mr. Keller it is now possible to approach without fear the construction of a three-phase furnace having a capacity of 20 tons; this furnace would necessitate the use of about 1800 kw; such a furnace would be capable of purifying 250 to 300 tons per day of ordinary basic converter steel in a series of heats which would last about 1½ hours each, and which would bring the sulphur content of the molten steel from the converter from 0.08 to 0.02 per cent approximately, at the same time permitting the deoxidation and decarbonization as required.

The cost of work of this kind would vary from 15 to 20 francs per ton of steel treated, calculating electric energy at 0.015 francs (0.3 cent) per kw-hour, a price which is possible with gas engines supplied from blast furnaces if no charge is made for the gas, and estimating the other factors of cost at a price corresponding to their usual value.

The passage of steel through the electric furnace, where under the influence of superheating, it would be subjected immediately, and by a rapid process, to a marked desulphurization, would permit the use in the converter of a cast iron richer in sulphur. This advantage would enable a metallurgical plant, taking advantage of this circumstance, to use ores which otherwise would have been rejected, and thus the introduction of the electric furnace in such works would have a two-fold and important economic application.

### Girod Electric Steel Furnace.

A description of his electric steel furnace was the subject of a paper by Mr. PAUL GIROD, managing director of the Société Anonyme Electrometallurgique Procédés Paul Girod, Ugine, France. This furnace has already been described before in our Vol. VI, pages 428 and 516, and our Vol. VII, page 9.

The working portion, or hearth, of the Girod furnace consists of a circular or oblong chamber filled with molten metal to a depth of 25 to 30 cm (12 to 14 inches). One or more electrodes of like polarity are suspended above the bath; the other pole or terminal consists of a number of pieces of soft steel buried in the refractory material of the hearth at its periphery, the upper ends of which come into contact with the metallic bath. The electric current forms an arc between the upper electrode and the surface of the bath, through which it passes to the connecting pieces of soft steel to the other terminal.

The upper portions of these connecting pieces directly in contact with the metallic bath naturally fuse to a certain depth. This does not, however, exceed two to four inches, as has been demonstrated by sections made of these pieces after several months' use. In order to decrease the depth of the used portion as much as possible, and to assist in preserving the lower portion of the refractory lining of the furnace, the lower extremities of the connecting pieces are fitted with a water-cooling arrangement in a cavity about 6 in. deep in that portion of the steel connectors projecting outside of the furnace; this also serves for connecting the cable to this terminal.

If a number of electrodes are used above the bath they are all in parallel. The furnace may be run with either continuous or alternating current, but in the latter case it is necessary to take into account that the power factor will be about 0.88.

The furnace chamber is a metallic shell made of plate steel, lined with magnesite or dolomite.

A cover lined with silica brick is mounted over the furnace, the ports for the electrodes being fitted with a removable cast-iron water-cooled frame.

The electrodes are so fitted that air cannot enter the furnace. This and the use of metallic frames or collars is rendered possible by the fact that the electrodes have the same polarity, and there is, therefore, no danger of short circuits across the cover. The use of metallic frames for the electrode ports is not altogether necessary, but has the advantage of more perfectly closing the furnace and stiffening the cover.

A great advantage of this type of furnace is the perfect ease with which it may be started up with cold charge. As there is only one drop of potential at the top, regulation is easy. On account of the low voltage of the furnace (55
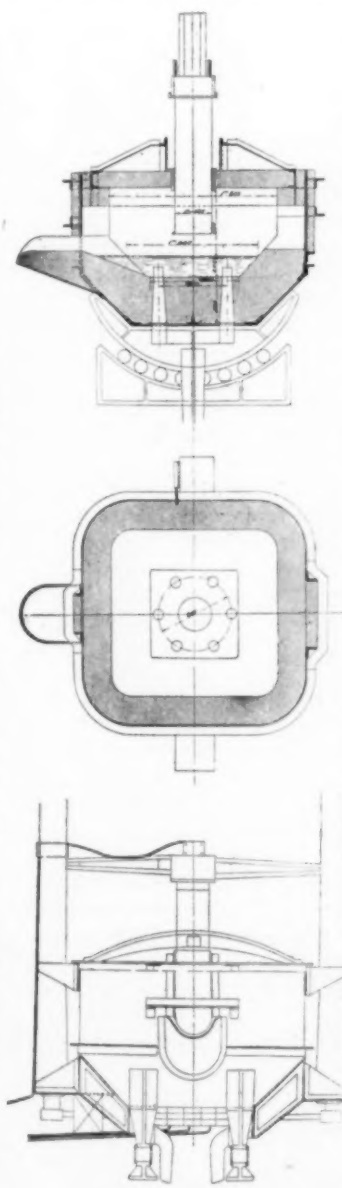


GIROD FURNACE.

volts) perfect insulation is easier than with double the voltage.

The following data has been taken from Girod furnaces in actual operation at Ugine, in the works of the Compagnie des Forges et Acieries Electriques Paul Girod.

One of these furnaces has now been working for several years and has never given the slightest trouble.

The raw materials at Ugine consists of scrap, turnings and some cast iron, gathered indiscriminately in the market. The problem, therefore, is to refine these materials, charged cold, to obtain a high-grade steel.

The average analysis of raw materials is 0.4 to 0.5 C, 0.15 to 0.25 Si, 0.5 to 0.7 Mn, 0.06 to 0.09 S, and 0.08 to 0.10 P. The finished steels are of any desired grade, of all degrees of

hardness; carbon and special structural steels, tool steels, cast steels, etc.

From the physical tests of the steels produced Mr. Girod claims their characteristic features to be a high elastic limit and great resistance to shock. "Compared to Bessemer, open-hearth or crucible steels, these qualities seem due to the chemical purity of electric furnace steel, to its homogeneity and freedom from occluded gases. The two latter points are of greater importance inasmuch as the sulphur and phosphorus content hardly ever exceeds 0.030 per cent anyhow."

The average energy consumption for fusing, refining and finishing a charge of cold scrap is 900 kw-hours in a 2-ton furnace and 700 kw-hours in a furnace holding 8 tons to 12 tons, the energy being measured at the furnace terminals. These figures will, of course, be slightly increased in the case of special steels, or diminished as the refining period is shortened.

The electrode consumption is about 16 kg to 18 kg (35 lb. to 40 lb.) in a 2-ton furnace, and 13 kg to 15 kg (29 lb. to 33 lb.) in an 8-ton to 12-ton furnace per ton of steel produced. The unused portions of the electrodes, corresponding in length to the height of the arched cover above the bath, are included as having been actually consumed. This refers to ordinary amorphous carbon electrodes, made from retort carbon and not graphitized.

The lining is of brick (or better still a paste) made of magnesite or dolomite. These materials give equally good results, and, therefore, the one is used which can be had at the lowest price. In France, the dolomite is generally used, as the price is very much lower than magnesite.

One such lining will last 40 to 50 heats without any repairs, after which the lateral walls of the furnace receive partial repairs. Now and then, generally after 100 heats, the upper portion of the hearth lining for a distance of about 10 cm (4 in.) is repaired also; after having scraped and cleaned the hearth, magnesite or dolomite is rammed in for a height of about 10 cm, taking care to preserve the passage for the metallic contact pieces.

The hearth otherwise does not require any other repairs than fixing up the sides for the distance of 10 cm. Thus, in the oldest furnace in use at Ugine the same hearth has been in place for over two years without having necessitated repairs.

The cover is of silica or high-grade firebrick, the life depending upon the quality of the brick; with good material a cover will last through 40 to 50 heats. Under these conditions, in France, the expense for furnace linings will be 7 to 8 francs ($1.40 to $1.60) per ton of steel produced in a small furnace, and 4 to 5 francs (80 cents to $1) in a large furnace of 8 to 12 tons capacity.

To handle the furnace three men are sufficient: a melter, an assistant melter, and a boy for a small furnace, four men for a large furnace. At Ugine the large furnaces are charged by an electric charging machine.

To the expenses above mentioned should be added the sundry additions, such as lime, ore and fluorspar, for the various slags, on one hand, and ferroalloys, ferromanganese, ferrosilicon, silico-manganese, etc., added during the final period and finishing off the metal, on the other hand.

The loss in the furnace will depend mostly upon the composition and state of oxidation of the scrap and materials charged; with heavy scrap, but little oxidized, the loss is from 6 to 7 per cent.

In the case of simply smelting a charge of cold scrap (selected and sufficiently pure not to require refining),the time of the heat is diminished by 25 per cent and the various above expenses of melting are reduced to 75 per cent of the above values.

If the electric furnace process consists of treatment of molten steel from the converter or open-hearth, the time of the heat is reduced to 20 or 30 per cent of the length of a heat required with cold charges, and the various factors entering into the cost are brought to 20 or 30 per cent of the above values. The en-

ergy consumption, the carbon consumption and repair costs of the furnace are very much reduced by the fact that the furnace is kept constantly hot, there being no important drops in temperature as in the case of cold charging, a condition unfavorable both from the point of view of energy consumption and preservation of lining.

Mr. Girod then gives a review of the various Girod furnaces in commercial operation (see our Vol. VI, p. 469 and Vol. VII, p. 9) and tables of the different steels made at the Girod works.



PAUL HÉROULT.

They range from extra soft to hard (0.08 to 0.06 C.), the sulphur being from 0.010 to 0.017, and the phosphorus from 0.005 to 0.012; also five grades of nickel steel and nickel-chrome steel (the composition of the latter being 0.420 C, 0.199 Si, 0.500 Mn, 0.010 S, 0.009 P, 0.77 Cr, 2.53 Ni). The Girod works also produce various kinds of tool steels.

Mr. Girod finally gives a table showing the results of mechanical tests of his steels to substantiate his claims mentioned above.

### Heroult Electric Steel Furnace.

Mr. ROBERT TURNBULL, resident engineer in America for Dr. Paul Héroult, presented a paper in which he first outlined the
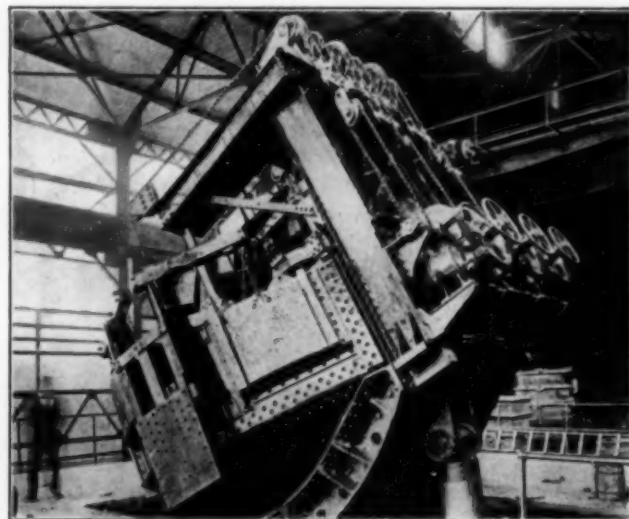


TILTING 15-TON HÉROULT FURNACE AT SOUTH CHICAGO.

reasons why Dr. Héroult decided to adopt his particular type of furnace.

In his aluminium process patented in 1887, Héroult employs a furnace of the crucible or pot type, consisting of a metallic

casing, the bottom of which was carbon lined forming one pole, while the movable carbon or electrode dipping into the charge to be reduced and melted formed the other pole. This furnace was the basis of his work on special alloys, such as aluminium-bronze and silicon bronze, etc.

Later when the problem came up of producing low-carbon ferrochrome, he had to abandon the carbon bottom and find another construction. His first attempt in this direction was to use a bottom lined with chromite, with a carbon rod in the center forming the lower pole of the furnace. His idea was that part of the carbon would be taken up by the metal and would be replaced by the metal itself, this process going on until the metal reached a sufficient depth where, owing to the outside radiation, it would freeze and remain in this state, thus forming the passage for the current and preventing the contact of the carbon with the molten metal.

This scheme, although giving certain results, was soon abandoned, and after some months of experimenting the present furnace was invented. The advent of low-carbon ferrochrome brought with it the possibilities of producing other soft metals, and it was not long before Dr. Héroult was at work on the steel



REAR VIEW OF 15-TON HÉROULT FURNACE AT SOUTH CHICAGO.

problem, and as he already had his furnace the production of steel became very soon an accomplished fact.
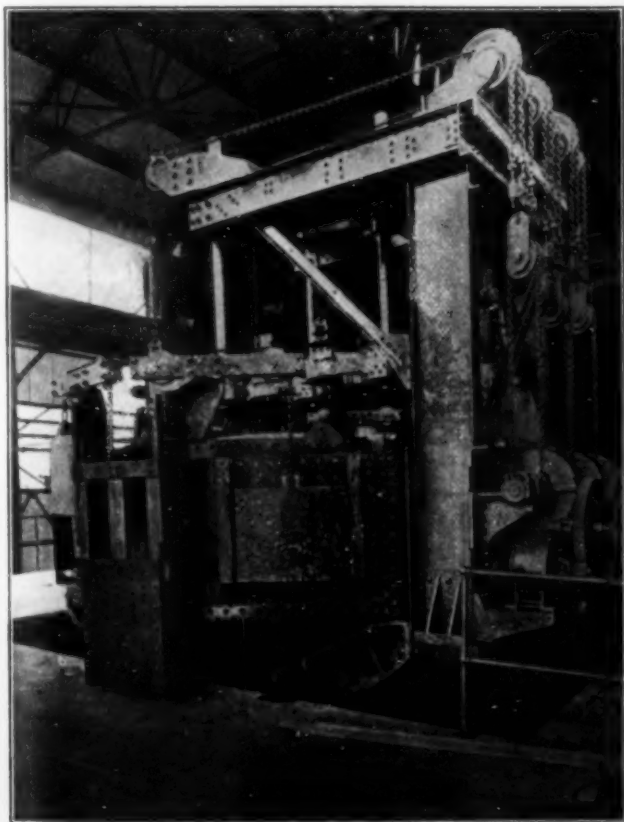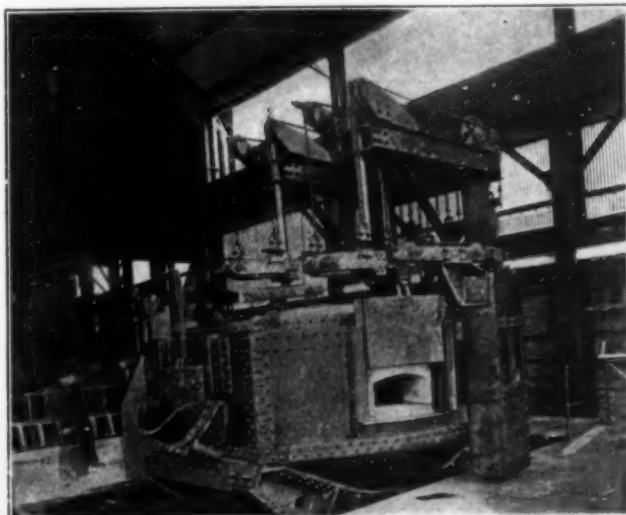
The main points which Dr. Héroult claims for his furnace are the following:

First—The total absence of electrical parts in the furnace proper, it being nothing else but a modified open hearth with the heat introduced above the metal by the electric current in place of gas. This in itself is an important factor, as it does away with the bottom pole, considered by Héroult to be always the cause of much trouble in electric furnace work, and allows of any patching necessary to the bottom or sides, without interfering with the work of the furnace.

Second—The heat being introduced by means of two electrodes working in series, the current passing through the bath from one electrode to another and vice versa, necessi-

tates carrying only one-half the current that would be the case should the current flow from one electrode through the bath and then through the bottom of the furnace if the power is the same in both cases. Thus all conductors are reduced to one-half the section required in the other case, and the elec-



SIDE VIEW OF 15-TON HÉROULT FURNACE AT SOUTH CHICAGO.

trodes can perform more efficient work owing to the lesser density of current to be carried.

Third—The possibility of refining impure metals and transforming them into the finest grade of tool steel. The heat being generated in the slag and not in the metal itself makes the slag the hottest part of the furnace, and all impurities can be removed by the use of special slags. This allows the use in the Héroult furnace of the poorest kind of scrap high in sulphur and phosphorus, both these impurities being removed at small cost.

Mr. Turnbull then gives examples from practice at La Praz of the refining possibilities of the Héroult furnace (see data of a complete month's results in our Vol. VI, p. 226).

The number of kw-hours necessary in the Héroult furnace to melt and partially refine one ton of steel is 600, 100 more being necessary for the finishing slag, making 700 in all. Those figures are for a five-ton furnace and starting on cold scrap; in the case of a 15-ton furnace they would be considerably reduced. Should the metal be charged hot into the furnace, that is to say, in a molten condition, and no other work be demanded outside the recarbonizing, desulphurizing and deoxidation of the steel, from 140 to 160 kw-hours are necessary in the five-ton furnace; for a 15-ton furnace this will probably be cut down to 100 kw hours.

The life of the electrodes depends on the conditions under which the furnace is run; in cold melting and continuous work the consumption is from 60 lb. to 65 lb. per ton of steel, but in cases where the metal is charged in the molten state this consumption would only be from 10 lb. to 15 lb. per ton, those figures including the part of the electrode which cannot be utilized.

The life of the lining depends entirely on the care with which the furnace is run; some linings will last for a year without being replaced, while others may have to be changed in three months. In this type of furnace a lining ought to last almost indefinitely, as it is exposed at no time to silicious slags and can be repaired after each heat by simply throwing in magnesite or dolomite as the case may be. The repairs are small; what suffers most is the roof, which has generally to be renewed once a month; as, however, a spare roof is always on hand, this can be done in a few hours.

As regards the best kind of lining for a furnace of the

Héroult type, good magnesite mixed with basic slag and using tar for a binder is about the best; burnt dolomite can also be used with good results. There is no mystery about this; any one who can make a good bottom in a basic open hearth can do the same in a Héroult furnace.

Mr. Turnbull finally referred to the adoption of the Héroult furnace by the United States Steel Corporation. As was mentioned before in this journal, two furnaces, each of 15 tons, are built at present; that at South Chicago was to be started on the day when the paper was presented, that at Worcester in July.

The steel to be treated at the South Chicago works will be brought direct from the Bessemers and two refining slags will be used in the electric furnace; the first an oxidizing slag to take out the phosphorus, the second a deoxidizing slag for the removal of sulphur and the gases.

The furnace is three-phase, the power being supplied by three transformers of 750-kw capacity each. It is expected to turn out 16 heats a day, or about 240 tons of steel. The electrodes, of which there are three, are the largest which have so far been built in one solid block, being 2 ft. in diameter by 10 ft. long and weighing something over 3200 lb. The current density will be about 28 amperes to the square inch, a figure which is considered a little high for the work, 25 being ordinary practice.

As to the maximum size of furnace which it is now possible to construct, it is the intention to build them up to 30 tons capacity. Very much will depend, however, on the work which has to be accomplished, that is to say, whether one or two slags would be used. In case of one slag Mr. Turnbull is sure that a 30-ton furnace is possible, but should two slags be used, owing to the difficulties which might be encountered in raking off the first slag, it may be found that a 15-ton capacity is nearing the limit. It could certainly be worked quicker than one of a 30-ton capacity.

In conclusion, on Dr. Héroult's authority, Mr. Turnbull extended a cordial invitation to all interested to visit the Héroult works at La Praz, France, where a careful study of his furnace and process can be made. "We have no secrets to conceal, the work is done openly and the operations can be conducted and controlled by the interested parties themselves, with the aid of our operators, and without any limit as to the duration of such operations."

### Discussion.

The discussion was opened by an excellent speech of Dr. JOHN A. MATHEWS, of the Halcomb Steel Company, of Syracuse, the pioneer electric steel plant of this country, where the Héroult process is in operation (see description in our Vol. V, p. 272). Dr. Mathews first criticized various general statements often made by electrometallurgists as not having been sufficiently substantiated by actual experimental data, though they may be substantially true. For instance, it is generally assumed or claimed for each electrical process that the superiority of its product depends upon the fact that the steel is melted in a neutral or reducing atmosphere and hence the product is better deoxidized and freer from dissolved gases. While this sounds reasonable and is probably true in most cases, no experimental proof or determinations of the gaseous content of electric steel have ever been given.

"As scientific men, I ask you whether it would not be a good idea to make an exhaustive investigation of this subject, and while we are about it make it equally exhaustive in regard to the gaseous impurities of steel made by the old processes. Would not an authoritative investigation of the subject be of tremendous interest and might not its results be of inestimable practical importance? Surely the desultory investigations that have been made of this subject for years past have been far from satisfactory and even the methods of determination are not above suspicion as to their accuracy. Moreover, the influence of the casting and subsequent heats has not been studied in its relation to the gaseous contents and mechanical properties.

"To my mind, an isolated test or two of the specimens of steel taken at random, said to be Bessemer, open-hearth or crucible, is of no value whatever. The whole history of the process by which it was made must be recorded. Such an investigation cannot be taken lightly; it will take years to com-
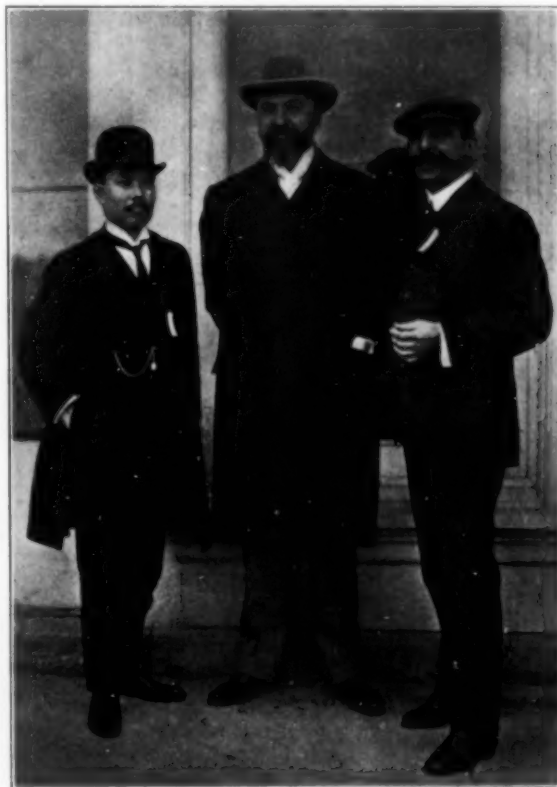


DR. BAEKELAND IN CENTER, MAJOR STASSANO AT THE RIGHT, DR. KATSURA AT THE LEFT.

plete; its outcome will be problematical, but is it not high time that it were begun? I have been pondering this subject in my mind for years, and am trying to develop a plan to undertake it. It is such a stupendous task that it cannot be done at odd times or in a college laboratory. Several workers must give their undivided attention to it for years. Are we ready for it? Would this society support me in the organization and direction of such a work? It ought to be undertaken under works conditions where the material can be watched from the beginning. As manager of a works where three distinct processes are in use, the basic open-hearth, the crucible and the electric, I feel it a solemn duty to undertake it."

As to electrical steel, Dr. Mathews believed that there was hardly room for reasonable doubts that several electrical processes are capable of producing steel fully equal to that of the older processes. To be sure there are still those who believe that good tool steel can only be made by various blends of Swedish irons; who claim that the results of melting hammered Swedish bars are much superior to those obtained by melting rolled bars of the same material; who talk wisely about "body" in tool steel, but who never define what "body" is. They remind one of a student who, when called upon to define space, said, "I can't exactly define space, professor, but I have it in my head."

Now, while it is true, that there seems to be an intangible something about tool steels which is not revealed by the ordinary analysis, yet the weak point in this talk about "body" is that it seems invariably to be developed in an astonishing degree in the particular brand of steel which the spokesman is

trying to sell. To Dr. Mathews' mind, "body" is more likely to represent the embodiment of the sum total of care used not only in the selection of raw materials, but also in the melting, cogging, rolling and annealing of the steel and in the selection of the right analysis for a given purpose.

Dr. Matthews then spoke of the relation of the electric furnace to the tool-steel industry. Naturally the original induction-furnace process as a simple melting operation had first appealed to him, but, on second thought, the question suggested itself: Why not use the electric furnace also for refining?

"One cannot wax enthusiastic in contemplation of a pile of muck bars—the crudest of all crude material in the steel industry. And yet, remelted in crucibles, they yield a product of great merit. The irregularity in composition of the product is objectionable, but this difficulty may be lessened by the use of Swedish bar iron, which is a reworked iron, much freer from entangled slag and more uniform in composition. In this country the use of Swedish iron is fast passing away; the crucible-steel industry of this country, with very few exceptions, is a mere business—not an art, as abroad. In the writer's works a Swedish iron is used which costs more in the bar than the finished product of some crucible mills seils for. They retain tenaciously the best traditions of English crucible-steel practice and methods, but they are not standing still.

"We have the first commercial electric furnace that was built in the Western Hemisphere. We are making steel in it, and good steel, too. To the best of my knowledge and belief it is chemically superior, and physically and mechanically superior to most, and equal to any, crucible steel made. I say this not boastingly, but as a scientific man addressing scientific men. Other electrical processes may produce as good steel, but I doubt whether the product of any gas or coke fuel furnace, no matter how choice the raw materials used, can more than equal it. I believe I am stating the case conservatively when I say that this product is as good as the best and all laboratory and practical tests of the product to date seem to point to this conclusion.

"But this was not always so. Some steel was made in our furnace in the early days that was not what it should have been. The electric furnace is a new thing; you must develop a practice with it as with other processes. It is not an automatic machine; we experienced trouble with it; it required care and study and practice. If one wishes to start a new open-hearth plant skilled men can easily be had; but if one starts an electric process, where will he look for experienced men? Unlike poets, they are not born, but made, and the making is not without expense, anxiety and some failures."

To one contemplating the installation of an electric furnace the choice of process depends upon many things—the material to be produced and the materials from which it is to be produced; the location; the source of power, whether bought or manufactured. It would appear that so far as types of furnaces and processes are concerned that we are now fairly well supplied; attention now must be devoted upon the part of inventors to improving the furnace design, the lining materials, the electrodes, if used, the power factor and thermal efficiency and thermal control. The user must develop his own works' practice, just as in past generations our predecessors had to do when the Siemens producer, gas-fired crucible furnace, graphite pots, acid Bessemer, acid Siemens-Martin, and later basic processes were new things and were looked upon with suspicion by many a good metallurgist.

Besides these remarks of Dr. Mathews there was very little further discussion. While practically every steel company in the United States was represented, their representatives preferred to remain silent.

To supplement Mr. Girod's paper reported above, Dr. Richards read a later communication from Mr. Girod giving some details of their method of deoxidation.

They never use metallic aluminium as a deoxidizing agent, but always alloys, for instance, 20 per cent Mn, 20 Si, 12 Al, the balance being iron. Another alloy contains 40 to 60 Si, 20 to 30 Al. Silicon is added preferably in form of high-grade ferrosilicon, 50 to 90 per cent. For making silicon steel they use 25 to 30 per cent ferrosilicon.

Mr. Girod also stated that he had observed that steel finished in the electric furnace from molten steel from the converter or open-hearth did not seem to be as good as steel made in the electric furnace from a cold charge. Though the steel may be apparently of the same chemical composition, the physical prop-



LOUIS SIMPSON.

erties are different. He could not give any exact reason, but it seems to him that the steel absorbs in the converter or open-hearth small amounts of certain elements which are not easily eliminated afterward. He prefers to make special tool steels from a cold charge in the electric furnace. The complete electrical treatment is more expensive, but, in Mr. Girod's opinion, it leads to better results.

As to the claim made in Mr. Turnbull's paper that a water-cooled bottom pole is always a trouble, Dr. Richards said that he had seen the Girod furnace and there was not any trouble to be found with its bottom after a whole year's working; the water-cooling is only on the outside.

### Thursday Afternoon Session.

The afternoon session was opened with an address by Mr. LOUIS SIMPSON, of Ottawa, Canada. Although Mr. Simpson's name has not often appeared in print (except as author of an occasional article like that in our Vol. II, p. 421), those who have followed closely the development of the electrometallurgy of iron and steel in recent years know that Mr. Simpson has been one of the most energetic driving forces in this movement and has been preëminently active in arousing the interest which now exists in Canada in this new industry. He recently resigned as general manager of the Montreal Cotton Company in Valleyfield in order to devote all his time to the promotion of an electric iron and steel industry in Canada.

Mr. Simpson spoke in his characteristic manner of the special conditions in Canada which promise a commercial success for an electric iron and steel industry; good ores and cheap water-powers are available, and coal is expensive. He expressed the conviction that it would be found practicable to make nickel steel directly from ore in the electric furnace. He stated that there are quite a number of electric steel furnaces now working in Sheffield, while in continental Europe the development has gone still further.

Mr. Simpson sketched his plan of an electric iron industry in Canada. It includes a water-power development of 80,000 hp.

Mr. L. Simpson's optimistic speech was generously applauded.

Four papers of Mr. Gin were then presented in abstract by Dr. Richards, Mr. Lidbury, Mr. Saunders, and Mr. Bennie.
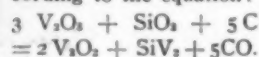
### Silico-Vanadium.

A paper by Mr. GUSTAVE GIN, of Paris, states that he has obtained the silicide $SiV_2$ by reducing in an electric furnace a mixture of vanadic acid, silica and coke according to the equation:

$$3 V_2O_5 + SiO_2 + 13 C = 2 V_2O_2 + Si_2 + 13 CO.$$

This amounts to approximately 10 parts of vanadic acid, one part of silica and one part of coke, by weight. Mr. Gin used a current density of 1290 watts per square inch of cross-section of the electrodes, but found that a notable amount of the vanadic acid was volatilized. The volatilization is very much reduced by using vanadium trioxide according to the equation:

$$3 V_2O_3 + SiO_2 + 5 C = 2 V_2O_2 + SiV_2 + 5CO.$$

GUSTAVE GIN.

By using commercial raw material, Mr. Gin has obtained a silicide containing vanadium 71.16 per cent, iron 5.40 per cent, silicon 22.16 per cent, carbon 0.72 per cent.

The manufacture of the double silicide of iron and vanadium is more easily accomplished than that of the silicide of vanadium, when reducing vanadium trioxide by means of rich ferrosilicon. The brittle 60 per cent ferrosilicon is powdered and mixed intimately with vanadium trioxide. This is agglomerated with 4 to 6 per cent of coal-tar pitch and molded into briquets or oval balls, which are charged into a double-hearth furnace with a rammed magnesite bottom.

Reduction takes place according to the formula.

$$4 V_2O_3 + 4 FeSi_2 + 5 C = Fe_4 Si_2V_6 + V_2O_3 + 7 SiO_2 + 5 CO.$$
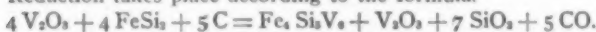
Mr. Gin has thus produced a silicide containing vanadium 45.04 per cent, iron 33.52 per cent, silicon 19.40 per cent, carbon 0.62 per cent.

Vanadium silicide, or the double silicide of iron and vanadium, may also be produced in the electric furnace by the reaction of trioxide or tetraoxide of vanadium with carborundum, or of a mixture of carborundum with rich ferrosilicon.

### Vanadium.

A paper by Mr. GUSTAVE GIN, of Paris France, deals with an electrolytic method of producing vanadium, using a principle analogous to that employed in the manufacture of aluminium. He uses vanadium trioxide as the solute in the electrolyte and calcium fluovanadate $V_2F_6$, $3 CaF_2$ as the solvent. Carbon anodes are used.

The lining of the bath consists of pure electrically fused alumina agglomerated with tar and a little vanadic anhydride. When heated to a bright red, a strong and compast mass is obtained.

The cathode is formed by cone-shaped conductors of pulverized and agglomerated ferro-vanadium, which pass through the lining material and come out flush with its surface. At their lower parts these conductors are bedded in graphite resting upon a copper plate connected with the cable to the negative pole of the generator. The metal first deposits upon the upper ends of the cathode cones which become covered with solid sheets which continue to enlarge until they meet together.

The metal cannot be tapped since the necessary temperature would be above that of the volatilization of the bath. When a sufficient quantity of metal has been deposited the electrolytic bath is emptied and the metal allowed to cool. The bottom of the furnace is then removed and the plate of metal separated from the adhering cathode tips.

The best current density is 4.5 amp per square inch of anode section.

### Low-Carbon Ferro-Alloys.

A paper by Dr. GUSTAVE GIN, of Paris, France, refers to a method employed in some ferro-alloy works where low-carbon ferro-alloys are made in two steps. First, the mineral is reduced by carbon and a ferro-alloy, relatively high in carbon, is produced. The accumulated slag is then removed and ore is placed upon the surface of the high-carbon metal so as to oxidize gradually the carbon contained in the ferro-alloy.

It is generally admitted that such decarburization requires a prolonged superheating, and it might seem that the decarburization becomes more easy and complete as the temperature of the bath is more elevated.

Mr. Gin thinks that the conditions are more complicated, since the carbon content is reduced not only by a superficial reaction between the metal and the fused slag in contact therewith, but also, and perhaps in larger measure, by an intermolecular reaction between the combined carbon and the oxide dissolved in the metal.

While it is probable that the amount of oxide dissolved in the fused iron bath increases with the temperature, it does not follow that the actual reaction between oxygen and carbon really takes place at the highest temperature. According to Mr. Gin this reaction really takes place during cooling and becomes strongest just before the fused bath becomes solidified. He refers to the fact that when ferro-chrome containing carbon is superheated in the presence of an oxidizing slag and when the entire mass is allowed to cool, it is regularly found that, on cooling down, the surface of the previously tranquil bath begins to boil, at first slightly, but the boiling increases more and more in intensity until immediately before solidification.

Mr. Gin thinks it likely that this ebullition is caused by the disengagement of oxide by carbon, due to deoxidation of the dissolved oxide by the carbon present in the alloy. This paper does not contain, however, an actual proof of this theory, though he refers to the opinion advanced by Le Chatelier that an increase of temperature favors endothermic reactions and a lowering of temperature exothermic reactions.

### Self-Circulating Electric Furnaces.

A paper by Mr. GUSTAVE GIN, of Paris, describes a method of producing automatic circulation in electric furnaces. The
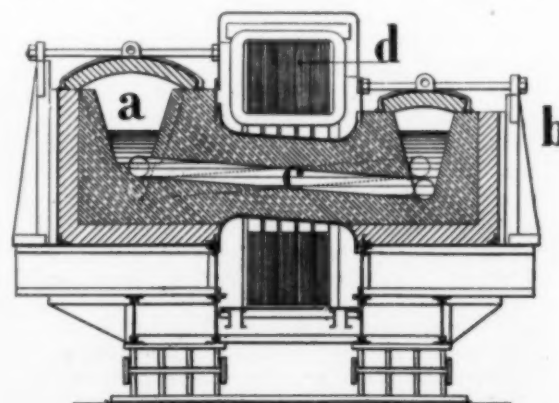
SELF-CIRCULATING INDUCTION FURNACE.

method is first described as applied to the induction furnace.

The furnace has two principal receptacles $a$ and $b$ united by two heating canals $c$. The vessel $a$ is larger than $b$, and is called the working bath; it carries a tap door for lag and an-

other for steel. The induction bobbins $d$ surround the two heating conduits $c$ and are cooled by forced ventilation. The whole furnace is mounted on an axle, so as to tilt it for running off slag and metal.

As is indicated in the illustration, one connecting channel $c$ is inclined downward from left to right, the other (shown by dotted lines) from right to left. The circulation is produced simply by differences of specific gravity.

In the second part of the paper the same method of self-circulation is applied to an electrode furnace, and in the third part to a combined induction and electrode furnace.

### Induction and Combination Furnaces.

A paper by Dr. F. A. KJELLIN was a full account of the development of the Kjellin and the Röchling-Rodenhauser electric furnaces. The first part of the paper, which was presented by



E. A. COLBY.

Mr. John Hay, of the Gröndal-Kjellin Company, dealt with the simple induction furnace as invented in 1887 by Mr. E. A. Colby in this country and independently reinvented 12 years later by Dr. Kjellin in Sweden.

At the Gysinge plant in Sweden, the induction furnace has been used for years for the production of high-class steel from cold scrap and cold pig iron. The raw materials being white Dannemora pig iron from Gysinge ore and Walloon bar ends. Owing to the rather high price of bar scrap they have in later years sometimes worked the furnaces with cold pig iron and very pure iron-ore briquets (made by the Gröndal briquetting process). According to their experience, the quality of the steel made from pure ore briquets is the same as when scrap is used.

The necessary theoretical power per ton of steel produced from cold pig iron and scrap is about 489 kw-hours. The furnace at Gysinge consumed about 800 kw-hours per ton when working with cold pig iron and scrap. When cold pig iron and iron-ore briquets were used the power consumption per ton of steel was increased about 50 per cent.

Some advantages of the induction furnace over the crucible furnace are as follows: In the induction furnace the steel can be better protected against injurious effects than even in the crucible. It allows tappings which are very large compared with the contents of a crucible, and the steel seems to be of even better quality than steel produced in crucibles from the same raw materials. Dr. Kjellin cites two striking examples.

In one case it was found that a bar of electric steel, 1 in. square, with over 2 per cent of carbon, could be twisted cold so that it looked like a corkscrew. This could not be done with crucible steel of the same composition. In another case a tool-steel maker found that he could reproduce his tool steel in the induction furnace with less additions of silicon and manganese than was necessary in the crucible.

The only probable explanation Dr. Kjellin can think of is

that the higher heat in the induction furnace expels a portion of the gases dissolved in the steel and perhaps also facilitates the removal of the combined oxygen, so that the deoxidation is more complete than that obtained in the crucible during that period of melting which the Sheffield steel makers call "killing."

A list of 14 induction furnaces is then given, of which two are no longer working. Their aggregate charge is 31,900 kg and their aggregate power 4030 kw.

The second part of the paper deals with the Röchling-Rodenhauser combination furnaces which was specially invented to refine molten steel from the Bessemer converter. For detailed descriptions see our April issue, p. 171, and our Vol. VI, pp. 10 and 458. The operation is as follows:

After tapping, fluid steel from the converters is poured into the furnace and suitable materials—burned limestone and mill-scale—for forming a dephosphorizing basic slag are added. When the reactions are ended this slag is taken off by tilting the furnace.

For making rails the phosphorus is brought down sufficiently low in one operation, but for making of the higher classes of steel the operation has to be repeated.

When the phosphorus is removed, the carbon in the steel (if carbon steel is made) is adjusted by adding pure carbon to the bath, and afterward a new basic slag is formed in order to remove the sulphur. This slag is also formed in order of burned lime, sometimes with the addition of fluxes, such as fluorspar.

One necessary condition for successful desulphurization is that the slag is free from iron, and therefore sometimes ferro-silicon is added in order to quicken the reduction of the iron in the slag.

The adjoining table gives all details regarding power, frequency, power factor, production and cost of plant for different sizes of three-phase combination furnaces:

| Contents, lbs. | Kw. | Electric Data, Volt. | Cyc. | Cos φ | Tapping lbs. Cold charging. | Hot charging. | Output per 24 hrs. lb. Cold charging. | Hot charging. |
|---|---|---|---|---|---|---|---|---|
| 2,200 | 175 | 500 | 50 | 0.8 | 1,540 | 2,200 | 9,240 | 35,200 |
| 6,600 | 350 | 3,000 | 50 | 0.6 | 4,620 | 6,600 | 27,720 | 106,600 |
| 11,000 | 550 | 3,000 | 25 | 0.65 | 7,700 | 11,000 | 46,200 | 176,000 |
| 15,400 | 750 | 3,000 | 25 | 0.6 | 10,870 | 15,400 | 64,680 | 246,400 |

The weights given are calculated at six charges per 24 hours for cold melting and 16 charges for hot melting, whereas the



F. A. KJELLIN.

actual times are 3½ hours per cold charge and 1 hour and 20 minutes for hot charge.

The voltage can be altered to suit circumstances, 12 per cent to be allowed for regulation.

| | P. | S. | Mn. | C. |
|---|---|---|---|---|
| Basic Bessemer steel charged into furnace having | 0.08 | 0.08 | 0.5 | 0.1 |
| Can be finished for rails, with 100 to 125 kw.-hours per ton, to | 0.05 | 0.04 | 0.8 | 0.5 |
| Or for quality steel, with 300 kw.-hours per ton, to | trace. | trace. | 0.25 | 0.05 |

*Open-Hearth Steel.*—Martin steel which has been previously refined, dephosphorized and desulphurized, containing 1.22 carbon, 0.38 Mn and 0.209 Si, has been put into the electric furnace and allowed to remain there to remove gases, regulate the carbon and adjust the alloys, with an energy expenditure of 200,250 kw-hours per ton.

The costs of production are then given for a 2-ton, three-phase furnace producing steel for steel castings. The raw material is fluid steel from the converters. The power price is taken at 9 pfennig (2.18 cents) per kw-hour. The life of the lining is taken at 10 days, in which time 160 tons can be produced. The cost of operation, including the lining, power, wages and materials for the slag (but no charge being made for the converter steel itself) is $8.82. To this is to be added interest (5 per cent) and depreciation (10 per cent) of the plant, making a total of $9.23 per ton. For working the furnace three men are required. The time required for the removal of the lining is 24 hours.

In another table the production costs of a 7-ton, three-phase Röchling-Rodenhauser furnace are given. In this case the power is supposed to be generated with blast-furnace gas engines and the cost of power is taken at 0.03 francs, or 0.58 cent, per kw-hour, or, say, $51 the kw-year. In this case the ton of steel comes out as $18.62 for rail steel and $19.78 for



TILTING AN 8-TON RÖCHLING-RODENHAUSER FURNACE.

soft boiler-plate steel. These figures include the charge for the molten Thomas steel ($15.54).

It is said that the Röchling-Rodenhauser type of furnace has now been so thoroughly tested in continuous work that there is no doubt about its reliability. The 3- to 5-ton furnace was worked continuously for a whole year, almost all the time producing steel for rails, and more than 5000 tons of rails have been sold from Völklingen to different customers at profitable prices.

For some time past steel made in a Röchling-Rodenhauser electric furnace has been manufactured into rails of standard section No. 8 for use on the Prussian State Railways.

The administration of the Prussian State Railways has drawn up specifications with reference to electric furnace steel rails, particularly as to physical qualities and resistance to wear, as follows:

"Tensile strength for track rails, a minimum of 70 kg per square millimeter, or about 99,000 lb. per square inch.

"For point or switch rails, 75 kg per square millimeter, or about 160,000 lb. per square inch.

"For ordinary basic Bessemer or Thomas rails a tensile strength of 60 kg per square millimeter, or about 85,000 lb. per square inch, is stipulated.

"Elongation, in the case of electric steel rails, a minimum of

10 per cent, determined on samples 200 mm (about 8 in.) between marks.

"Drop tests specify 80 mm minimum bend (about 3 3/16 in.) on a bar 1 m (39.37 in.) between supported ends, with a falling weight of 1500 m-kg (about 10,800 ft.-pounds).

"Guaranteed life of track rails, 10 years; or point rails, seven years."

The chief differences between ordinary Thomas steel rails and electric steel rails are shown in the following table, the figures being mean values:
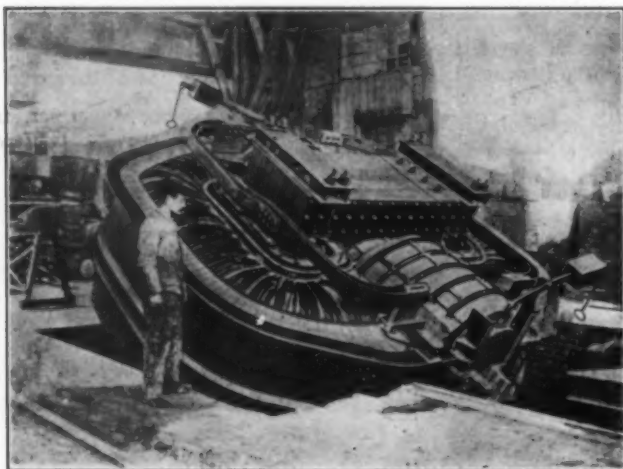
| | C. | P. | S. | Mn. | Si. | Tensile strength, lbs. per sq. inch. | Elongation, per cent. | Contraction, per cent. |
|---|---|---|---|---|---|---|---|---|
| Electric steel... | 0.54 | 0.056 | 0.042 | 0.984 | 0.21 | 119,000 | 15.4 | 24.1 |
| Thomas steel.... | 0.36 | 0.073 | ..... | 1,127 | .... | 97,000 | 17.6 | 26.2 |

The composition of the electric steel rails is similar to ordinary Thomas steel rails, the higher carbon content corresponding to the specified higher tensile strength. "The favorable result of the electric steel rails can only be obtained through the 'killing' of the material in the electric furnace under a slag which facilitates deoxidation and escape of gases."

## The Pinch Phenomenon in Electric Furnaces.

A paper by Mr. CARL HERING, consulting engineer, of Philadelphia, deals with the working limit in electrical furnaces due to the "pinch phenomenon." The pinch phenomenon itself was described in Mr. Hering's paper in our Vol. V, p. 223.

On the basis of Dr. Northrup's mathematical theory of the pinch effect, Mr. Hering has derived a method of calculating the critical current density which can be used in an electric furnace. The fundamental idea is simply this: The pinch effect produces a pinch pressure which sucks the liquid from the center and forces it out near the ends, thus producing a difference in level which is equivalent to a hydrostatic pressure. A condition of equilibrium is reached when this hydrostatic pressure just balances the pinch pressure.



FIG. 1.—PINCH PHENOMENON FOR CIRCULAR CROSS-SECTION.

For a circular cross-section the results are plotted in Fig. 1. where the vertical distances $d$ represent the differences in levels in centimeters for an original depth of 10 cm of liquid and the horizontal ones represent pressures in pounds per square centimeter. Let the liquid be mercury.

The hydrostatic pressure increases in direct proportion to the depth and is, therefore, represented by a straight line $Op$, which is quantitatively correct for mercury. The "pinch" pressures are independent of the specific gravity of the liquid, being dependent only on the current and the cross-section. Calculating these for the various differences of levels gives for a current of, say, 10,000 amp, the curve $ab$. This curve merely gives the pressures which that particular current would produce if the column had contracted (from any cause whatsoever) to

those differences of level, or had those respective cross-sections originally.

Equilibrium will be reached when these two opposing pressures balance each other; that is, at the intersections of this curve with the slanting straight line $Op$. It will be seen that there are two such points, $x$ and $y$, hence there are two different levels for the same current.

It can be easily seen that for the higher level $x$, which in this particular case means a depression of 1.2 cm, the equilibrium is stable, while for the lower level $y$ the equilibrium is unstable. That is, if equilibrium $y$ is disturbed the contracted section will become smaller and smaller and rupture will take place.

It will be seen, therefore, that the current may be well within the safe limit, causing only the upper, small and perfectly stable level, yet if some mechanical force then acts to
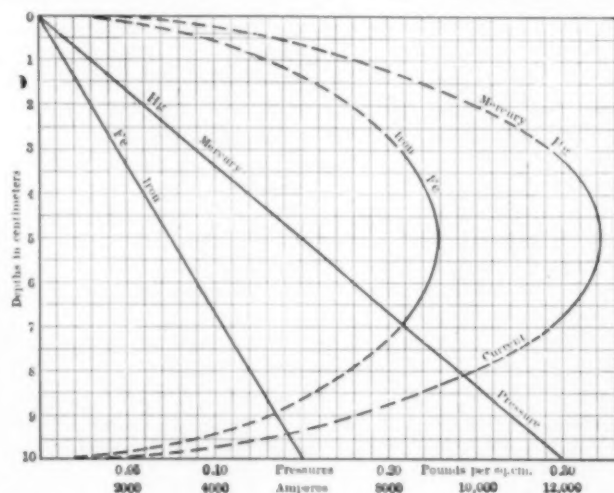


FIG. 2.—PINCH PHENOMENON FOR RECTANGULAR CROSS-SECTION.

depress the level to a lower point, the unstable level may be reached in which case the same apparently safe current will be sufficient to cause the rupture. Such a mechanical depression could be produced by some floating infusible material, a loose fragment of firebrick, etc., or by stirring with an insulated rod in a narrow channel. It is, therefore, not always safe to conclude that if the normal current produces only a slight depression, there is no danger of rupture.

By drawing the corresponding curve for 5000 and 1000 amp it will be seen that these two points of intersection move further apart as the current diminishes, which means that a disturbance of the level becomes less dangerous. On the other hand, the curve for the greatest possible current of about 12,500 amp, becomes tangent to the straight line at $t$, which means that the two points have come together.

By calculating the currents required to reduce the levels to the various depths $d$, the curve $OCP$ is obtained, the horizontal distances of which are currents instead of pressures. The curve is seen to be re-entrant, returning back to zero. Starting at $O$, where there is no depression, it will be seen that the current must be increased to large values before any marked contraction occurs. After that, however, the level falls quite rapidly with a small increase of current, until the maximum possible current is reached at $C$, after which even a smaller current will again be sufficient to balance the increasing hydrostatic pressure, because the cross-sections are less and the current densities are greater. The lower part of the curve is, however, only of theoretical interest, for at the maximum point $C$ the state of unstable equilibrium begins, and in practice rupture, therefore, immediately follows; hence this lower half of the curve in practice becomes a vertical line $CP$.

If a horizontal line is drawn from the upper point of intersection $x$ of the pressure curve for 10,000 amp, to the current curve, it will be found to intersect it at 10,000 amp, as it should.

The same is true of the lower intersection or of any of the others; and the pressure curve for the maximum current of about 12,500 amp, will be tangent to the straight line at $t$, namely, at the same level as the maximum point, $C$, which important point is termed the *critical point*.

For materials of different densities the hydrostatic pressure is, of course, proportional to the density, but the current is proportional to the square root of the central pressure and therefore to the square root of the density; hence the currents for the critical point will not vary as rapidly as the densities of different materials.

The curves in Fig. 2 give the actual figures for a rectangular channel 10 cm deep and 5 cm wide when the conductor is mercury. The scales and co-ordinates are the same as in Fig. 1. The straight line $Hg$ gives the hydrostatic pressures at the various depths. The current curve $Hg$ is shown dotted where its shape is not known, and in full where it can be calculated with close approximation by the Northrup formula.

It will be seen that the critical point is reached when the contraction has lowered the level to 5 cm, just half the original depth. The maximum current then is 12,900 amp. Moreover, the contraction increases very rapidly just prior to this current, hence it would begin to be unsafe long before this level has been reached.

If $G$ is the density and $H$ the original depth of the liquid conductor in centimeters, the critical current density $CD$ in amperes per square centimeter is:

$$CD = 221 \sqrt{G/H}.$$

For a small trough 2 in. deep and 1 in. wide the critical current would be about 3300 amp. For 4 x 2, about 9400 amp. For 6 x 3, about 17,000 amp. About 75 per cent of these values would probably be a safe working limit if the channel is quite uniform, if the surface of the molten liquid is reasonably free from floating, heavy, non-conducting materials and if the liquid is not too viscous.

Since the theory is based on ideal "static" conditions, Mr. Hering has made a series of actual tests under actual "dynamic conditions," due to the rapid agitation which always accompanies the phenomenon. The tests were made on a small scale with mercury and the results were given in an appendix to the paper. The chief result is that in using the formula in the paper one will be on the safe side in practice.

From the results of these tests it would seem that the width of the channel has no effect on the critical current density, or, in other words, that the critical current increases in direct proportion to the width. The tests were not accurate enough to show whether this was strictly correct.

It would also seem that for a given area of cross-section the critical current would be the same whether the channel were made deep and narrow or wide and shallow.

Changes in the proportion of the height and width seem to have only a small influence on the maximum possible current density; therefore, the best possible shape of a rectangular cross-section probably depends on other considerations, like the loss of heat, which is least when the cross-section is a square. Another factor which may be even more important is that the shallower the channel the greater is the danger due to the contraction caused by obstructions or floating masses. The length of the channel also becomes an important factor, if, with a relatively deep channel, it can be made so short that the material displaced by the pinching effect piles up very high on both sides so that the hydrostatic pressure is rapidly increased; the critical current densities ought then to be very much higher. Confining the material in a covered channel, or using an external magnetic field, ought to enable higher current densities to be reached.

Mr. Hering's paper was discussed by Dr. Northrup, who thought that the theoretical formulas in the paper would probably prove more reliable in their application to large furnaces than deductions from the small-scale experiments.

Mr. FitzGerald mentioned that the largest scale on which

he observed the pinch phenomenon was when they tried to melt aluminium in a 60-kw induction furnace, the depth of the channel being 6 in. or 7 in., the width 2 in. Success of melting was prevented in this case by the pinch phenomenon.

### The Lash Process and the Electric Furnace.

Mr. F. A. J. FitzGerald, of the FitzGerald & Bennie Co. Laboratory, of Niagara Falls, N. Y., explained in an interesting paper in which way the Lash process, often before noticed in this journal, can be applied to the electric furnace.

The Lash process is based on the observation of Mr. Horace W. Lash that when an intimate mixture of iron ore, carbon, fluxes and cast-iron borings is heated, reduction takes place and by a suitable proportioning of the mixture the desired grade of steel can be obtained. Instead of cast-iron borings granulated or shotted pig iron may be used (which can be readily made with the aid of steam and is said to be supplied by pig-iron makers at the same price as ordinary pig iron). The important constituents of the mixture are, therefore, pig iron, ore and coke.

Hundreds of tons of steel have been made in the open-hearth furnace using the Lash process and it has been shown by experience that a superior quality of steel is obtained in this way and that the cost of producing the steel is in general lower than when the regular methods are employed.

In comparison with the open-hearth, the electric furnace has certain advantages for carrying out the Lash process. In the electric furnace the atmosphere is neutral, while in the open-hearth furnace it is oxidizing, thus making more difficult the proper control of the carbon content of the steel produced when the charge is melted down. In working with the open-hearth furnace it is necessary to use a certain amount of pig iron or scrap, or both, in addition to the Lash mixture, while in the electric furnace this should not be necessary, and since the cost of a unit of iron in the mixture is much less than in the form of pig iron or scrap, an economy would be introduced which would offset, at least to a certain extent, the high cost of generating heat electrically.

The experiments made by the FitzGerald & Bennie Laboratory with the Lash process in an electric furnace of the Héroult type were described in detail in our Vol. VI, p. 493. The energy expenditure was approximately 1.63 kw-hours per kilogram or 0.25 hp-year per metric ton.

Mr. FitzGerald then gave various tables of the composition of the Lash mixture when used in the open-hearth and in the electric furnace, and in comparison with the ordinary open-hearth process. These tables are summed up in the following table giving a comparison of different methods of producing 100 tons of steel ingots:

| Raw materials. | Open-hearth furnace, scrap and pig. | Open-hearth furnace, pig and ore. | Open-hearth furnace, Lash process. | Electric furnace. Lash process. |
|---|---|---|---|---|
| Pig iron | 50 tons | 94 tons | 60.1 tons | 40.7 tons |
| Scrap | 57 tons | .. | .. | .. |
| Ore | 2 tons | 26 tons | 75.2 tons | 103 tons |
| Coke | .. | .. | 13.4 tons | 19.5 tons |

So far as the open-hearth furnace is concerned nothing more can be expected in the application of the Lash process than is shown above. It may be that some further reduction in the amount of pig iron used may be reached.

The experiments with the electric furnace, however, have not been carried so far, and it is, therefore, probable that better results can be obtained than those indicated above. It may be possible, for example, to reduce the percentage of granulated pig iron used in the mixture. This possibility suggests the interesting question: Why use pig iron at all? Is it not possible in the electric furnace to use a charge consisting only of ore, carbon and fluxes?

The excellent and well-known work of Stassano has answered the latter question affirmatively, and he has shown that charging his furnace with a mixture of ore, carbon and fluxes, paying careful attention to the proportions, it was possible to produce steel of the desired grade. Seeking an answer to the first question, it must be remembered that Lash's experiments showed that when various mixtures containing different percentages of cast-iron borings were used it was found that the mixture which contained very little or no metallic iron failed to react in a satisfactory manner, and it was this result which in great part led to the development of the process in its present form.

If mercury and iodine are rubbed together in a mortar there is no appreciable reaction, but if the mixture is moistened with a little alcohol the mercury and iodine combine to form iodide. The analogy is very far from being exact, nevertheless it may be used in considering the Lash experiments. Apparently the presence of pig iron intimately associated with the mixture of ore and carbon assists in a marked way the reaction between these constituents of the charge.

Experiments have been made in the electric furnace by Mr. Robert Turnbull for the purpose of comparing the reaction of the Lash mixture and a charge containing no granulated pig iron. The results obtained confirmed the belief in the importance of the pig-iron constituent, for not only was the power consumption excessive where no metallic iron was used, but the mixture boiled or frothed in a very troublesome manner instead of melting down in a relatively quiet way, which is characteristic of the Lash process. Moreover, where no pig iron was used the consumption of electrodes, in a furnace where the heating is done by drawing arcs between the electrodes and the charge, is very much greater than when the Lash process is employed.

Therefore, in answer to the question as to why pig iron should be used at all, it may be replied that its presence reduces the amount of energy required to produce a unit weight of metal from the ore, and that, by making the reaction proceed more quietly and rapidly, it diminishes other expenses connected with the working of the electric steel furnace.

### Large Electric Iron and Steel Furnaces.

A paper by Mr. Remo Catani, of the Société Elba, of Elba, Italy, emphasized that if the electric furnace is to compete with other processes for iron and steel production it must be of large capacity.

In a paper read before the Associazione Electtrotecnica Italiana (see our April issue, page 153), the author has shown that blast-furnace pig iron and electric pig iron have the same cost price when

$$y = x\left(0.115 + \frac{4}{n}\right)$$

where

$x$ is the cost of a hp-year, in lire.

$y$ is the cost of a ton of coke, in lire.

$n$ is the number of kilograms of pig iron produced per hp-day ($n = 8$ represents at present quite good electric furnace practice. Dr. Héroult hopes to get $n = 12$, since he expects 120 tons of pig iron per day from a 10,000-hp plant).

In the above formula it is assumed that the gases of both blast and electric furnaces are entirely utilized in gas engines, and a year is composed of 8000 hours.

For a given value of $x$ or $y$ the value $n$ varies hyperbolically with $y$ or $x$. This fact proves the importance of furnace efficiency in the economic study of electric pig iron.

The author has further found that if only blast-furnace gas is utilized, the preceding formula is to be changed as follows:

$$y = x\left(0.185 + \frac{4}{n}\right)$$

for which we have, for $n = 12$ (Héroult's figure) very approximately $x = 2y$. This means that electric pig iron should cost as much as blast-furnace pig iron when the price of a hp-year is twice the price of a ton of coke, and the electrothermic reduction of iron ores should be cheaper than that in a blast furnace when a hp-year costs less than two tons of coke.

The author then discusses the importance of increasing the

power factor so as to have it as nearly equal to unity as possible. This may be accomplished either by lowering the frequency or the coefficient of self-induction. To lower the coefficient of self-induction is a more interesting problem than to lower the frequency, because very often it is a question of making a larger electric furnace using a given current, but even when the installation is being designed it is not convenient for the electrical machinery to use a very low frequency. The author considers 25 cycles as the best frequency for electrometallurgical purposes.

In the last part of his paper Mr. Catani discusses single-phase versus polyphase current operation for large electric furnaces. With reference to a certain 7000-hp, three-phase furnace, built in Sweden, for carbide manufacture, the author claims that if it was changed to single-phase operation it would have a capacity of 12,000 hp instead of 7000 hp without any change in its dimensions.

A three-phase furnace versus a single-phase furnace of the same power presents some peculiar features, of which some are considered as advantages and others as inconveniences.

The advantages of three-phase are: Neutrality of the hearth; greater facility of making the furnace rotary, above all if electrodes remain in their lines during the rotation; cheaper electrical machinery (alternators, line, transformers, etc.). As inconveniences of three-phase may be considered the following features: Larger cross-section of electrodes put in furnace; greater number of electrode holders or larger electrode holders in an unfavorable position, being exposed to the radiation of the furnace; necessity of running to full load or overload in order to have a good efficiency; possibility of short-circuits through the walls of the furnace without passage of the current through the bath; larger dimensions of the furnace.

In studying the means of reducing the coefficient of self-induction it is to be remembered that it depends upon the permeability and that it is necessary to avoid in the furnace construction any material of high permeability, at least in the loop formed by the conductors of the current.

"From these considerations is derived the possibility of making very powerful electric furnaces, much more powerful than those built up to now, corresponding to the very large electrical powers actually reached in steam or water turbines, alternators, transformers, etc., and we hope that if such powerful electric furnaces will be built, electric furnaces will produce iron and steel at as low a price as the best common metallurgical furnaces."

### The Present Value of Electric Srtuctural Steel.

Mr. HENRY D. HIBBARD, consulting engineer with the Taylor Iron & Steel Company, thinks that possibly the electric smelting of steel, now entering the commercial stage, is in danger of having its progress retarded by the zeal of its friends, who may claim more for it in some respects than the future will justify.

The object of his paper is chiefly to compare from a cold business standpoint the value of electric steel with that of steel made by the Bessemer and open-hearth processes. Comparison with crucible steel is less needed because the differences are less.

The advantage which electric steel melting offers may in a general way be said to consist in the ability to melt or to retain melted a large quantity of steel in an environment either non-oxidizing or with access of oxygen to the metal under control, and also with controllable temperature in the metal, both as to degree and duration. The beneficial result of these advantages lies more in the direction of improved quality of the product than in lessening its cost.

The specific features of electric furnace operations which tend to improve the product are the elimination of oxidation products, of phosphorus and sulphur, and, as a result therefrom, an improvement of its quality and a possibility of having less manganese in the finished metal.

**Oxidation Products.**—These are the most uncertain of all the poisons to steel, because they are not determined and are dealt with by indirect methods. They may be itemized as being chiefly oxides of iron, manganese, silicon and carbon, and silicates of the two metals mentioned. The usual analysis does not reveal the presence or amount of these oxidation products.

With respect to these oxidation products which seem unavoidable in the oxidizing atmosphere of the converter and open-hearth, the reducing atmosphere of the electric furnace is of chief importance.

The electric furnace in dealing with the oxidation products in crude steel enables the fusion to be continued at will until they are removed as completely as desired through agglomeration and gravitation, or by their reduction to elements through the action of some reducing element at the high temperature maintained.

Another matter comes in here, however, for consideration. If steel containing less than the usual amount of the oxidation products be found to have for that reason increased commercial value, something can be done when using the Bessemer and open-hearth processes to attain some of that value, especially with the latter by proper treatment of the slag and bath, and by allowing enough time. "If the electric steel furnace induces consumers to pay for high quality, it will, indeed, have justified its existence. Until then its value, because of its ability to eliminate oxidation products, bust be held as not determined."

**Phosphorus.**—The basic open hearth can now produce regularly from the very ordinary materials steel so free from phosphorus that very little is left for the electric furnace to do even if it were possible by its use to remove every atom. "The value of the ability of the electric furnace to make structural steel exceedingly low in phosphorus cannot be great from a commercial point of view."

**Sulphur.**—The effect of sulphur on the physical properties of the finished steel is so slight that satisfactory reasons do not appear for closely limiting and specifying its permissible content. As in the case of the oxidation products, the trouble from sulphur is more in evidence during manufacture than in the finished steel. "The power of the electric furnace to eliminate sulphur from steel, while undeniable, must be held, nevertheless, as of little real value until the minimum attainable in the open-hearth process is shown to have an important detrimental effect on the product." * * * "It must be undubitably shown that the properties of the finished steel are better than those given by other methods at about the same or lower cost before the electric furnace can take its place as one of the standard commercial means for producing or finishing structural steel."

"It is stated that the German Government is paying $4 a ton more for rails rolled from electric steel than for ordinary rails. Such action might be for either of two reasons: First, that the electric steel rails have been demonstrated to be worth that additional price, or, second, that the $4 amounts in part at least to a Government subsidy aimed to put forward the development of the electric furnace. As the final test of a rail consists in wearing it out by actual service, which can hardly have been done yet, it would seem fair to assume at this time that the $4 includes a subsidy. The total amount of such subsidy cannot be very large up to date."

### Discussion.

With respect to Kjellin's paper the question was asked as to the material from which the pole-pieces or pole-plates (through which the current is introduced into the working hearth) are made. Mr. Hay replied that they are made from cast steel, but are not in direct contact with the fused bath. They are protected by a lining made from magnesite and tar; under the action of the heat the tar disappears. The magnesite conducts when heated. The rest of the lining in the furnace is dolomite.

With respect to the Lash process Mr. FitzGerald explained that if sufficient quantities of cast-iron borings should not be

available, granulated pig iron could easily be used. There is no difficulty in making it. A convenient method is to pour the metal, while a jet of steam is directed on it at a right angle.

Mr. Lane emphasized that there was a sufficient supply of borings and turnings, and the process seemed to solve the problem what to do with them, especially for manufacturers of small castings.

Dr. R. Moldenke concurred with thim in this view; he considered that for manufacturers of small castings the electric furnace as an auxiliary might be valuable, by buying steel ingots, heating them almost to the melting point in a regenerative furnace. finishing in an electric furnace and then casting. Such a process would be economical.

With respect to the doubt expressed by Mr. Hibbard whether electric steel refining would be really commercially worth the cost, Dr. Richards replied the best answer was the existence of some 80 electric furnaces in regular commercial operation.

Mr. Anthony Victorin gave a graphical representation of what the electric furnace can do under the conditions existing in a steel casting plant in Philadelphia. He compared the open-hearth process, the Tropenas converter, these two processes combined with the electric furnace, and finally the all-electric process, plotting graphically the possible commercial profits. His results appeared quite favorable to the electric process.

This closed the symposium of papers on the electrometallurgy of iron and steel. As specially interesting to steel men the following paper on pyrometry was then taken up:

### A New Radiation Pyrometer.

A recent modification of the Féry radiation pyrometer was described in a paper of Mr. CHARLES E. FOSTER, of the Taylor Instrument Companies, of Rochester, N. Y.

While in so-called optical pyrometers, the radiation corresponding to a certain wavelength serves as indication of the temperature on the basis of Wien's law, the basis of the temperature measurement in the radiation pyrometer is the total radiation acording to the Stefan-Boltzmann law.

In the original Féry radiation pyrometer the radiation is concentrated on the junction of a small thermo-couple. The electromotive force set up in the couple by the heat is indicated by a galvanometer, which is connected by leads with the pyrometer, and which has carefully to be levelled. In the new type, which is also due to Professor Féry, a small strip made up of two metals having very different coefficients of expansion, and coiled to the shape of a spiral, replaces the thermo-couple. The spiral unrolls when heated, and a pointer marks this movement on the scale. The temperature of the air must be taken into account by adjustment of the zero of the instrument. The great advantage of the new type over the older one is that it is an absolutely self-contained instrument.

As far as tests go the instrument keeps up its calibration very well. At 1000 deg. C. the accuracy is well within 2 per cent.

The paper was discussed by various speakers, who related chiefly their experience with optical and radiation pyrometers.

### Furnace Electrode Losses.

Mr. C. A. HANSEN, of the research laboratory of the General Electric Company, presented a very interesting paper, giving in a long series of diagrams the results of an extended investigation of the losses due to the electrodes in an electric furnace. There are two kinds of losses: Joulean heat developed by the electric current in the electrodes, and heat transferred by conduction from the hot inside of the furnace to the cold outside.

That the conditions are quite complicated became evident in the early experiments of the author, when he found in a special case the striking result that by increasing the effective resistance length of the electrode and increasing the current density so that the Joulean heat losses were more than doubled, the total electrode loss was not increased. Assuredly, then, in this case

the efficiency was increased by increasing the length of the electrode embedded in the wall.

Later, in another experiment, an even more surprising result was encountered when it was found in one case that the cooling water from the outside electrode water-jacket carried off less heat than corresponded to the Joulean heat developed in the electrode itself by the current. The inference is, of course, that "the electrode is at least as hot as the furnace interior by reason of the $C^2R$ heating and not alone blocking the flow of heat from the furnace outward, it actually feeds heat in both directions, the main portion naturally going to the cooling water-jacket."

A large part of the paper is devoted to a comparison between amorphous carbon and artificial-graphite electrodes. The chief conclusions of the author are as follows:

For electrodes in the furnaces with which he experimented carbon electrodes are less wasteful of heat than graphite electrodes of the same cross-section at current densities below 200 amp per square inch. Varying the length of electrode may, to some extent, vary this critical current density.

In furnaces taking 500 kw, the electrode losses can easily reach 15 per cent of the total load impressed. Since the electrode losses are to a certain extent independent of the length of the furnace, if we shorten the furnace we increase the electrode loss to any amount above 15 per cent.

It also seems more reasonable to assign a ratio of the heat conductivities of graphite and carbon of about 8 to 1 under the conditions described. The ratio is brought down to this value from 18 to 1 (cold) probably owing to the partial graphitization of the carbon, and the ratio may also vary somewhat with length.

Mr. Hansen also gave many interesting diagrams, showing the variations of various physical properties of carbon and graphite with temperature.

The paper brought out a very extended discussion in which Messrs. Lidbury, Hering, Richards, Northrup, Hansen and others participated. Mr. Hering pointed out that if one makes one point or portion of the electrode hotter than the inside of the furnace, this will act like a "heat valve," heat flowing off from this point toward the inside of the furnace.

### Electrochemistry and the Conservation of Natural Resources.

In the evening or Thursday Dr. E. G. ACHESON delivered his presidential address on the function which electrochemists will have to fulfill in the movement toward the conservation of our national resources.

The opening thought of Dr. Acheson's address carried him back in memory to the joint conservation conference held in Washington, D. C., in December of last year. He told how he felt a thrill of pride in being one of the people of the United States when President Roosevelt stated this nation was first to take steps to conserve natural resources. It was with profound pleasure that he realized that the people of the United States are now great enough to call a halt in the heedless consumption of the world's stock of necessities; rich enough to construct great works for the attainment of that end; scientific enough to create artificial duplications of the natural and add to the list of the materials nature has provided for man's use, and, lastly, humane enough to devote some thought, work and resources toward providing for posterity.

Dr. Acheson reviewed briefly the work of the conference, pointing out the disposition to create expensive waterways, but the failure of the body to take steps looking to the actual conservation of our perishing resources caused regret and surprise. It was his expressed belief that to fully utilize the natural inexhaustible resources, while conserving the natural exhaustible resources, would be an example for the entire civilized world to follow, and a step well calculated to sustain the progessive spirit of Americans. He felt it was possible for Americans to

build as no other people have built, and he pointed out how this might be done through the aid of electrochemistry.

It was evident that the retiring president of the American Electrochemical Society had most carefully studied the "great open door" before that organization, and in more than one way he told how wonderful things might be accomplished.

An illustration was made in connection with the sodium nitrate field. The center of this new industry is now in Norway, but the speaker's words intimated that he wondered how long Americans would submit to this condition. Dr. Acheson emphasized that at the present rate of importation the next 20 years would call for the sending of no less than $473,650,495 out of the country, a sum, he coolly stated, quite enough to dig the Panama Canal and leave a good balance to the country's credit.

Dr. Acheson then outlined the logical course to pursue in the conservation of natural resources. His plan involves forest creation and protection, the impounding of waters, the construction of power plants, and lastly the development of waterways, ushering in the electrochemical age. With this Dr. Acheson associated a new synthetic chemistry, providing wonderful possibilities. Electrochemists are even now earnestly at work on



PRESIDENT E. G. ACHESON.

problems of great magnitude, citing the electrometallurgy of iron and steel.

Leaving the question of conservation, Dr. Acheson turned again to electrochemistry, saying the field is much too extensive and rich to be monopolized by any one or two of the professions. He portrayed a brilliant future, and in conclusion he said: "The government will, I think, ere long recognize the electrochemists, and our society in particular, as an important factor in the industrial and commercial life of the nation, and as a means of materially conserving the interests of posterity. It may be that it will in time see the advisability of establishing a department devoted to these interests."

### Friday Session.
### Ammeter For Large Alternating Currents.

A paper by Dr. E. F. NORTHRUP, of the Leeds & Northrup Company, of Philadelphia, describes a new type of ammeter for the accurate measurement of alternating currents over 1000 amp. The instrument is based on the "pinch effect" or (what is at the bottom of this effect) the centripetal pressure which exists in the interior of a liquid conductor carrying an electric current.

The field of special usefulness of this new instrument is to be found in the accurate measurement of alternating currents of over 1000 amp, there being no assignable upper limit to the current which may be measured. It is especially suitable for determining exactly the transformation ratio of heavy-current series transformers. The fundamental principle is indicated in the adjoining illustration, where $B$ is a vertical section and

$A$ a cross-section on the line $ab$ of $B$. $Hg$ is a cell filled with mercury. When an electric current passes from $j$ to $k$ through the mercury, a difference of hydrostatic pressure is created between the outer and inner circumferences of the circular
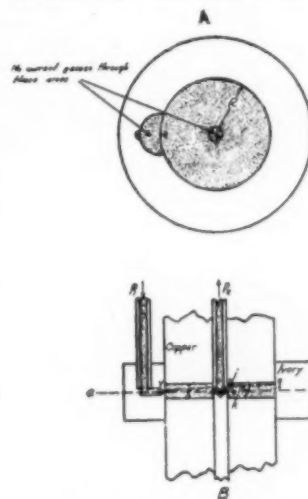


PRINCIPLE OF AMMETER.

cell. In order to determine this pressure-difference a communication must be established between the inner and outer circumferences of the cell. This may be accomplished by the arangement diagramatically shown in the section $B$. When the current flows, the mercury will tend to flow down the tube $p_1$ and up the tube $p_2$. This flow will continue until the difference in level at which the mercury stands in the tubes $p_1$ and $p_2$ establishes a pressure-difference equal and opposite to that produced by the curent between the inner and outer circumferences of the cell. By measuring the difference in level between the tubes $p_2$ and $p_1$ the pressure-difference produced by the current and, therefore, the current itself may be determined.

In order to magnify the difference in the level of the mercury a column of colored water is used as indicator. The mercury well, which communicates with the center of the cell, is given a large diameter and the surface of the mercury in this well only rises a fraction of a millimeter when the water column rises 50 cm or more. With this construction the friction which the surface line of the mercury makes with the wall of the well is vanishingly small and has no influence on the precision of the indications or on the accurate return to zero of the water column when the current is turned off.

The theory of the instrument is given in detail, and an account is given of the many difficulties which had to be overcome in the mechanical construction, but which have now been overcome successfully. The instrument can be made so exact that it may be used for an absolute measurement of current. The arrangement of the instrument for this purpose is described.

### Electroplating.

A paper by Dr. EDWARD F. KERN, of the School of Mines, Columbia University, pointed out the importance of smooth, solid, coherent deposits for electroplating as well as refining, and discussed in detail one of the means to this end, namely, the addition of certain reagents (gelatine, tannin, etc.), which, when present in very small quantities, often improve the quality of the deposit in a very effective manner. Such materials the author calls "addition agents."

Dr. Kern first gives a review on the literature of the subject and then an account of an extensive experimental investigation made by him in conjunction with measures of Janis, Fabran and Frapwell.

For depositing copper, lead and silver the following electrolytes were employed: cupric sulphate, cuprous chloride and cupric fluo-silicate; lead nitrate and lead fluo-silicate; silver nitrate and silver fluo-silicate. The addition agents tried with these electrolytes were gelatine, resorcinol, pyrogallol and tannin.

For deposition of nickel the following electrolytes were employed: nickel fluo-silicate, nickel chloride, nickel sulphate and nickel fluo-borate because of their higher solubility and their cheapness of preparation.

For the deposition of iron, experiments were made with fer-

rous sulphate and ferrous chloride solutions. The results of this experimental investigation are as follows:

The deposits of lead, copper and silver tend to form more crystalline and less coherent with higher current densities. The smoother deposits form with lower current densities.

With rise in temperature of the electrolytes of lead, copper and silver, up to 60° C., the tendency of the depositions is to form more coherent, denser and less crystalline.

The fluo-silicate electrolytes of lead, copper and silver give more coherent deposits than those formed in the nitrate electrolytes of lead or silver, or in the sulphate or chloride electrolytes of copper.

The crystallization of the deposits of lead, formed in an almost neutral electrolyte of lead nitrate, is restrained by having present one part of either tannin, resorcinol, pyrogallol or gelatine per 250 parts of electrolyte. The deposits, however, in all cases were composed of a mass of non-coherent crystals. Tannin is the most satisfactory "addition agent" for lead nitrate electrolyte.

Gelatine, tannin and pyrogallol when present in lead fluo-silicate electrolyte in the proportion of one part by weight to 5000 parts of electrolyte causes the lead to deposit as a smooth, dense, coherent mass. The most effective of these "addition agents" is gelatine, the next is tannin, and the least effective is pyrogallol. Resorcinol is not a suitable "addition agent" for this electrolyte.

The deposits of copper, from copper sulphate electrolytes, are rendered smoother and brighter by the presence in the electrolyte of either tannin, resorcinol or gelatine; tannin is the most effective, resorcinol is less, and gelatine is the least effective of the three. Pyrogallol is not a suitable "addition agent" for this electrolyte, as it causes the deposited copper to form dark colored.

The deposits of copper from copper fluo-silicate electrolyte were rendered smoother and brighter by the presence in the electrolyte of either tannin, pyrogallol or gelatine. Tannin is the most effective of the three.

The deposits of copper from cuprous chloride electrolytes are not improved by the presence in the electrolyte of either gelatine, pyrogallol or dextrine. Elevation in temperature of this electrolyte does not cause the copper to deposit more coherent.

EFFECT OF ORGANIC ADDITION AGENTS IN THE ELECTROLYTES OF LEAD, COPPER AND SILVER.

| Electrolyte. | Gelatine. | * Tannin. | Pyrogallol. | Resorcinol |
|---|---|---|---|---|
| PbSiF₆ | Densest depot | Denser deposit | Dense deposit | Deposit not improved |
| CuSiF₆ | More smooth and bright deposit | Most smooth and bright deposit | Smooth, dense deposit | Deposit not improved |
| Ag₂SiF₆ | Coherent deposit | Deposit not improved | Deposit not improved | Deposit not improved |
| Pb(NO₃)₂ | Less crystalline and more coherent deposit | Deposit much improved | Deposit not improved | Deposit not improved |
| AgNO₃ | More coherent deposit | Deposit not improved | Deposit not improved | Deposit not improved |
| CuSO₄ | Brighter and smoother deposit | Brighter and smoother deposit | Dark deposit | Deposit not improved |
| Cu₂Cl₂xNaCl | Deposit not improved | Deposit not improved | Deposit not improved | Deposit not improved |

Silver is deposited as finer crystals and in a more coherent form of electrolytes of silver nitrate and silver fluo-silicate, when the electrolytes are at a temperature of 40° than when at a temperature of either 20° C. or 60° C.

Deposits of silver from silver fluo-silicate electrolyte are more coherent than deposits formed in silver nitrate electrolyte.

Gelatine, when present in silver nitrate, and in silver fluo-silicate electrolytes, in the proportion of one part per 10,000 to 14,000 parts electrolyte, causes the deposit to form as shorter and as smaller crystals, which are more coherent than when gelatine is not present.

Pyrogallol, tannin and resorcinol are not suitable "addition agents" for silver nitrate or fluo-silicate electrolytes.

The presence of free acid in nickel chloride, nickel sulphate and nickel fluo-silicate electrolytes causes very low cathode efficiency, whereas the anode efficiency was in most cases over 95 per cent. By continued electrolysis the free acid was neutralized and the cathode efficiency increased. The electrolysis of neutral nickel chloride and nickel fluo-silicate solutions with current densities of 10 and 20 amp per square foot gave very satisfactory deposits and high current efficiencies. Neutral nickel-sulphate solutions were unsatisfactory, as precipitates of insoluble basic salts formed and intermixed with the deposited nickel.

Heating the nickel chloride and the nickel fluo-silicate electrolytes decreased the e.m.f., increased the efficiencies and improved the deposition. The most satisfactory temperature was about 40° C.

During electrolysis of nickel fluo-silicate solutions a small amount of gelatinous silica separated and collected on the bottom of the cells. Heating of these solutions above 75° C. also caused the separation of silica, but very slowly.

A small amount of basic salts separated from the neutral nickel chloride electrolytes during electrolysis, but did not interfere with the deposition. The presence of a small amount of free acid prevented their formation.

The presence of sodium salts in the nickel chloride electrolytes was not very beneficial, whereas its presence in the neutral sulphate electrolytes reduced the e.m.f. over 60 per cent, caused the formation of good deposits and also increased the current efficiency to approximate 100 per cent, when the temperature of the electrolyte was about 60° C. At room temperature the presence of sodium salt in the sulphate electrolyte was of no great benefit.

Satisfactory deposits of nickel were obtained from neutral solutions of nickel fluo-borate electrolytes when the electrolysis was conducted at room temperature and using a current density of 10 amp to 15 amp per square foot. At temperatures above 35° C. the solution was decomposed, causing the precipitation of an insoluble basic salt.

Good deposits of iron were contained by the electrolysis of neutral electrolytes containing either 8 per cent of iron as $FeSO_4$, or 6 per cent Fe and 3 per cent Na as sulphates, or 8 per cent Fe and 4 to 7 per cent Na as chlorides. The presence of the larger amount of sodium chloride in the electrolytes prevented the vertical ridging of the deposit and caused it to form smoother. The finer-grained deposits of iron from the sulphate electrolytes were formed in the solutions which contained the sodium salt.

The deposits of iron formed in neutral chloride electrolytes containing sodium chloride were finer grained and more flexible than those formed in the neutral sulphate electrolytes.

The deposits of iron formed smoother when the electrolysis was conducted at 40° C. to 60° C. than when conducted at normal temperature.

The effect which the presence of organic addition agents has upon the deposits of lead and silver from their fluo-silicate and their nitrate electrolytes and upon the deposits of copper from its fluo-silicate and its sulphate electrolysis cannot be attributed to any specific physical property of the addition agent. The only property in common of the organic addition agents which were found to be beneficial in improving the deposits of lead, copper and silver is the larger number and the similar arrangement of the hydroxyl radicals.

At the present time, with the lack of reliable data, the only means of selecting the most suitable addition agent is patient experimenting. However, this general statement may be made: That the greater the molecular weight of the addition agent and the larger the number of adjoiningly grouped hydroxyl (and amine) radicals which the compound contains, the more effective it is in producing denser, brighter, less crystalline and more coherent deposits of lead, copper and silver.

A theory which may be deducted from the above generalization is that the function of an addition agent, in an electrolyte, is to maintain a reducing menstruum around the cathode, which in turn causes the electro-deposit to form denser and smoother.

The author cites various facts and observations in support of this hypothesis.

## Deposition of Aluminium from Aqueous Solutions.

A paper by Prof. S. A. TUCKER and E. G. THOMSSEN, of Columbia University, described a method of depositing aluminium from an aqueous solution, which, while not of commercial value, is of considerable scientific interest.

From experiments carried on with copper and other metals deposited on a rotating cathode, it is known that the current density can be raised very greatly and the nature of the deposit be generally improved. It seemed possible that if the speed of rotation could be sufficiently increased the current density might be raised to such a high value that metals could be deposited from aqueous solutions which under ordinary circumstances would not deposit at all.

In the experiments cathode speeds up to 20,000 r.p.m. were used and minute deposits were obtained with higher speeds from a concentrated or pasty electrolyte. By chemical analysis these deposits were proved to be aluminium. On exposure to the air, however, the deposit blackened. Temperatures from 30 to 40° C. gave the best results. When using the highest speeds it was possible to burnish some of the deposits which were slightly black on a buffing lathe with rouge, the deposit then having the same appearance as polished aluminium.

In the later experiments, which gave the best results, an anode of aluminium, a cathode of brass and an electrolyte of a pasty solution of aluminium chloride at a temperature of 30 to 40° C. were used with a cathode speed of 15,000 r.p.m. and an anodic current density of 0.085 amp per square centimeter.

In the discussion which followed Professor Tucker said that he has succeeded in depositing calcium, magnesium, etc., from aqueous solutions in the same way by the use of a rotating cathode. In the case of calcium Dr. Watts questioned whether the deposits consisted of metallic calcium, as it might have been a subchloride of calcium. As to aluminium Professor Tucker stated that the identity of the chemical deposit as metallic aluminium had been established by analysis.

Mr. A. H. Cowles referred to the alleged plating of the top of the tower of the Philadelphia Public Building with aluminium. True, the electrolyte was rich in aluminium, but also in tin; and it seems certain that the deposit produced actually consisted essentially of tin.

Mr. William Koehler said he had succeeded in depositing aluminium from a dilute chloride solution upon an iron cathode. While the process is not now a commercial proposition, it is possible.

## Electrolytic Deposition of Lead and Zinc.

A paper by Prof. S. A. TUCKER and E. G. THOMSSEN, of Columbia University, refers to a patent of Classen, according to which deposits of zinc can be much improved by the addition of licorice root or extract or other similar organic compounds to the electrolyte. The present authors have studied the effect of such additions on the deposition of lead and zinc.

They found that in the case of both lead and zinc the deposit actually obtained exceeded that of theory in nearly every instance. Of the two substances used, the licorice root gave higher results than the extract. The extract of licorice also gave better deposits than those obtained with the root. By a special investigation it was found that this excess of weight was due to organic matter (licorice) being carried over with the metal deposited.

The deposits in every case were exceedingly good, adhering firmly if the cathode was perfectly clean at the start and if the current density was not too high. The lead comes out unpolished, but with zinc, if the cathode is first polished, a bright coat of zinc is obtained.

When heated, the lead adheres until it fuses, while the zinc becomes brittle and peels off readily.

It is impossible to raise the current density to any great extent without impairing the deposit. With 2 amp per square decimeter the deposits become dark, rough and non-adherent. The best results were obtained with a current density of about 0.5 amp per square decimeter.

In order to secure a good, thick deposit of the metals it is advisable to add the organic matter gradually and to keep it well stirred.

In the deposit of zinc it was found that zinc sulphate alone, with the addition of licorice, gave quite as good results as when the electrolyte was made up with the additions as recommended by Classen.

## Acetone Solutions for Metal Deposition.

A paper by Dr. H. E. PATTEN and Mr. W. R. MOTT dealt with the electrodeposition of some metals from acetone solutions. They succeeded in depositing sodium and strontium metals from saturated solutions of the iodides in acetone at room temperature, using rather high-current density. Cadmium, tin, antimony, bismuth and arsenic were deposited from solutions of their chlorides in acetone at moderately low density.

Iron and copper were deposited from solutions of their chlorides (-ic) in acetone rather high current densities.

In most cases anode and cathode polarization values were obtained.

## Autographic Registration of Cooling Curves.

A paper by Dr. E. F. NORTHRUP, of Leeds & Northrup Company, of Philadelphia, first discusses the advantages of autographic recording apparatus (as distinguished from photographic recorders) and describes a new autographic recorder which will automatically and accurately register energy variations where the available energy is exceedingly small. If the variations in the energy are not too rapid, autographic recording
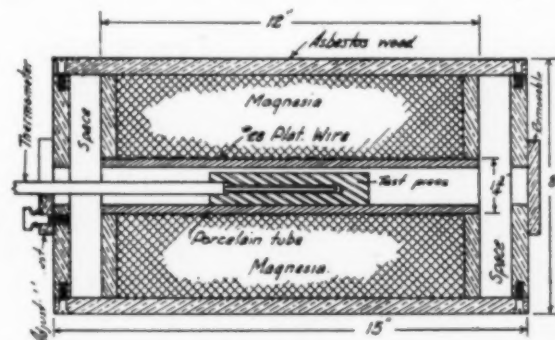


ELECTRIC FURNACE FOR DETERMINATION OF COOLING CURVES.

can be made to compete in all cases with photographic recording in regard to sensibility and precision.

The complete recorder consists of four essential parts: a differential galvanometer, with a plunger magnet attached to it, for operating periodically a contactor; an eight-day clock, which drives and operates the contacting plunger magnet; a simple mechanism consisting of a screw and two electro-magnets of the plunger type for traveling the pen and the balancing contact; and a paper drive, moved by the clock, which feeds a continuous band of paper off a roll and over an apron carrying it under an ordinary stylographic pen. All parts of the recorder are made up of separate, interchangeable units, which may be easily assembled, disassembled or replaced. The uninterrupted operation of the apparatus is absolutely assured.

Dr. Northrup then briefly discusses various forms of cooling curves and concludes that with a highly sensitive and accurate recorder, the temperature range of which can be modified at will, the form of cooling curve in which the temperature is plotted against time, will yield all the information desired and in a manner most simple and direct. He then discusses the use of electric resistance thermometers versus thermocouples for the

recording of cooling curves and gives various reasons why the resistance thermometer is preferable.

In the concluding part of the paper some practical suggestions are made on the recording of cooling curves of steel. The recorder described in the paper follows the cooling of a sample ½ in. in diameter when cooled in an oven well insulated from loss of heat by a jacket of magnesia. If it is required to take the cooling curves of sheet steel, this may be done by cutting a strip 5 in. wide off the sheet. This strip may be rolled upon a ½-in. mandrel to form a hollow cylinder and used in the oven in the same manner as a solid cylinder with a hole bored in it.

It is important for ease of working to have a properly constructed oven. On page 273 is given the design of an oven which is the outcome of considerable experience and many trials. The casing of the oven is made of a compound of pressed asbestos, known to the trade as "asbestos wood."

The platinum heating coil is wound on the outside of a glazed porcelain tube, the winding being distributed to give uniform temperature throughout the interior of the tube. The glazing is softened by high heat around the wire and retains it in place. The space around the porcelain tube is filled in loosely with powdered magnesia. The quantity of this magnesia may be varied to modify the velocity of cooling and may be removed with ease to inspect the winding or make repairs. A switch, binding post and fuse are mounted upon the outside of the case. The winding is of No. 28 platinum wire and has 11 ohms resistance at room temperature. Extra removable pieces of asbestos-wood permit the end opening to be closed tightly and yet allow the easy insertion and removal of the samples. When at full heat the oven operates directly in 110 volts.

With the outfit of recorder, thermometer and oven described in Dr. Northrup's paper, many samples may be tested in a single day, and the results obtained will be without ambiguity. Differences in the positions of the recalescent points of steel of 1 deg. C. are easily located with certainty. The curves which are drawn are drawn on thin semi-transparent cross-section paper and may be easily blueprinted for duplication. Tabulated cooling-curve records of this precision, accompanied with chemical analysis of the samples, ought to yield information of much value in the metallurgy of steel and its protean alloys.

### Electrolytic Deposition of Platinum.

A paper by Dr. W. J. McCaughey, of the Bureau of Soils, Department of Agriculture, describes a method of depositing platinum by electrolysis. The primary object was to secure a set of platinum-plated bottles in which to carry on solution studies. Gold is first deposited; although soft, it adheres firmly and offers an excellent surface upon which to build a harder deposit of platinum.

The electrolyte was formed by addition of citric acid to a saturated solution of potassium chlorplatinate. In general it was found expedient to use a solution of the following concentration: 2 grs. potassium chlorplatinate, 10 grs. citric acid, 100 c.c. water. This high proportion of citric favors the formation of a better deposit. The platinum content of the solution may be renewed as it becomes exhausted, but finally the solution ceases to give a smooth deposit. But a small amount of hydrochloric acid revives it by correcting the alkali environment formed at the cathode. The current density has an effect upon the deposit, a low current density gives non-adherent platinum. The effects of various other changes in the conditions are also described.

### White Lead.

Mr. John A. Yunck, of South Orange, N. J., discussed in his paper the electrolytic production of white lead on the basis of experience in a small plant making for several months about 50 lb. of white lead per day, equal to the best for covering and color qualities. The experiments were conducted at the laboratories of the late Rev. John B. Tibbits, at Hoosick, N. Y.

The apparatus consisted of a tank about 36 in. high by 24 in.

wide and 30 in. long (with glass sides to note the operation). Anodes of lead and cathodes of aluminium were cast in strips and grids connected at top and bottom, to facilitate continuous operation. The tank was water-cooled from the outside and at the same time a stirring device was placed in the bottom of the tank to keep the solution in a slow, steady motion.

Two solutions were used as electrolyte, one a 15 per cent solution of nitrate of soda, the other of nitrate of ammonium. The first was cheapest in first cost, though, in the opinion of the author, ammonium nitrate being a better conductor, it would be cheaper from a commercial standpoint to use it.

During electrolysis carbon dioxide gas was allowed to pass through the electrolyte from small orifices at the lower part of the tank. After running about 2½ hours the operation was stopped for about one-half hour to allow thorough settling, the solution was drawn off and the precipitated white lead was removed, washed and dried. The current density used was 10 amp per square foot anode surface at from 1 volt to 2 volts.

As the electrolyte is made up of sodium and ammonium nitrate in water, and the solution is saturated with free carbon dioxide, the reaction is assumed to be as follows: The solution is decomposed, yielding at the anode nitrogen pentoxide, oxone and oxygen, and at the cathode sodium hydrate, ammonium and hydrogen. The lead is attacked by the powerfully oxidizing pentoxide ($N_2O_5$) and ozone, since nitrogen pentoxide in the presence of water is decomposed and forms nitric acid ($HNO_3$).

During the double decomposition which takes place, nitric acid ($NHO_3$) and hydroxide of lead $Pb(OH)_2$ are formed. The nitric acid combines with the free ammonia and sodium hydrate to again form sodium nitrate, while the plumbic hydrate is precipitated by the free carbon dioxide present and forms finally the hydrated carbonate of lead $2 PbCO_3 + Pb(OH)_2$. In this way the solution is regenerated and the only materials consumed are lead, carbon dioxide and water.

By this process a white lead was produced finer than can be ground by any mechanical means, and the finer the particles the greater the covering properties. The best commercial white lead contains the greatest amount of water, the amount running up to 2 per cent. This quality is more or less difficult to obtain ordinarily, but in the electrolytic process is very easy.

The question whether the process can be carried out with a profit to the manufacturer is answered by the author in the affirmative. The electrical energy required per ton of white lead is about 16 kw-hours. There is only a loss of water and a small amount of carbon dioxide. The first cost of the plant is said to be very much less than that with the old method; in the latter capital is idle for months, while the electrolytic method can convert metal into carbonate from day to day.

The author refers finally to the production of colors, where the anodes were composed of bimetallic substances, lead in combination with copper, nickel or iron. By this means the author states that colors of the most delicate shades and tints can be produced, of different kinds, with ease. The precipitation being uniform when different electrodes and electrolytes are used, iron-oxide paints of particular richness in texture as well as color are produced this way, and very cheaply.

There were on exhibition various specimens of white lead and colors made by the author in this way. In the discussion Prof. C. F. Burgess expressed a doubt whether it would be possible to maintain continually the originally good condition of the electrolyte. He thought there would be danger of the electrolyte becoming fouled in time so that the desired quality of white lead could not be uniformly maintained.

### Western Standard Cell.

Dr. G. A. Hulett, of Princeton University, whose extended researches for a series of years have contributed so much to our knowledge of standard cells, presented in abstract two papers on the Weston cadmium standard cell.

The first paper referred to the e.m.f. of cadmium amalgams

of different concentrations. The second discussed one special point in the thermodynamical theory of the Weston standard cell, namely, the question whether the second form of the Gibbs-Helmholtz equation (including the temperature coefficient) contemplates a change of concentration of the electrodes.

In the discussion Mr. Hering suggested it might be practical to calculate formation heats from electrical measurements. Dr. Hulett replied that the difficulty was in the second term of the Gibbs-Helmholtz equation, being the product of the absolute temperature and the temperature coefficient of the e.m.f. A small mistake in measuring the latter might result in a large mistake in the product.

### Electrolytic Reduction of Nitric Acid.

A second paper on this subject (the first paper, see in our Vol. V, page 449) was presented by Dr. HARRISON E. PATTEN and W. J. McCAUGHEY, of the Bureau of Soils, Department of Agriculture, Washington, D. C. The chief conclusions are:

That ammonium sulphate in sulphuric acid solution is oxidized at a platinum anode, nitrogen gas being liberated.

That in the electrolysis of nitrate in sulphuric acid solutions containing copper sulphate, hydroxylamine is formed at copper cathode as an intermediate step in the reduction of the nitrate to ammonia; that nitrogen gas is liberated at the cathode; that the ammonia which diffuses over from the cathode is oxidized at the anode to substances which reduce permanganate; that nitrogen gas is evolved at the platinum anode.

The electrical and chemical and physical conditions under which these changes take place are defined in the paper.

It appears that nitrogen undergoing either oxidization or reduction probably goes through several of the intermediate stages, if not all, which exist between its initial and final state of oxidation.

### Electromagnetic Flotation Processes.

A very peculiar and interesting process is described in a paper by Mr. A. P. STECKEL dealing with the "electromagnetic separation of non-magnetic, non-conducting substances."

The method described was the result of a study of the problem of obtaining a more thorough concentration of Lake Superior native copper ores, carried out at the Buffalo Smelting Works during the last three years.

As shown, $A$ is an electromagnet, in the gap of which is a
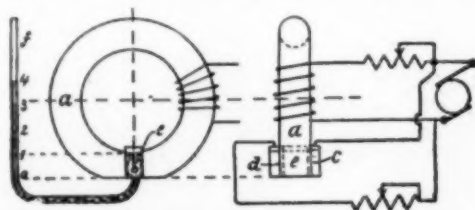


PRINCIPLE OF ELECTROMAGNETIC FLOTATION PROCESS.

trough $e$ of uniform cross-section made of insulating material and carefully leveled so that a liquid $b$ partially filling the trough shall have uniform cross-section. The liquid is water containing a few per cent of sulphuric acid to increase its electrical conductivity. At the ends of the trough, but purposely set somewhat inside the boundaries of the magnetic field, are carbon electrodes, $c$ and $d$, accurately fitting the trough and carrying direct current to and from the liquid conductor. The relation between direction of magnetic field and direction of current in the liquid is such that the force brought to bear on the liquid is downward. The object is to adjust at will by this electromagnetic means the apparent specific gravity of the acid solution, while any unmagnetic and non-conducting particles of ore, etc., are not affected.

The attachment $f$, shown in the figure, is a gauge glass for accurately observing the apparent specific gravity of the liquid. Before attempting to use the apparatus in concentrating ore

various interesting experiments were performed, pieces of glass and of rock as large as could be accommodated in the trough being floated on the water. On the other hand, wood may be made to sink to the bottom in mercury. If the flow of the current in one direction makes the liquid apparently heavy, then the reversal of the current makes it apparently lighter.

As first constructed the trough was 2 in. wide by 4 in. deep by 15 in. long. Although the performance above described was found possible with a trough of these dimensions, it was not possible to hold the liquid sufficiently quiet to even attempt a treatment of finely divided material. A flotation process, especially if fine particles are to settle, requires a quiet liquid, but the liquid under the conditions described above was far from quiet. At first it was thought that the violent agitation of the liquid was due primarily to the rise of gas bubbles at the electrodes, but after this source of trouble had been eliminated by the use of porous woolen screens near the electrodes, the agitation of the liquid was still quite violent.

There was always a tendency of the liquid to become depressed at the middle of the length of the trough and to rise at the ends with a consequent flow. This agitation could be somewhat overcome by strengthening the magnetic field at the ends.

A mixture of fine particles of copper and rock (15 per cent copper) was then put into the liquid to test the scheme of concentration. The presence of the material increased the general agitation somewhat, but it was also noted that each particle of suspended material had an irregular motion of its own. Although all the large particles of copper went to the bottom and all the large particles of rock stayed at the surface, there was not a satisfactory separation of the fine particles either of copper or of rock; in fact, an assay of the tailings skimmed from the top showed 5 per cent copper, all of which was composed of fine particles of copper not allowed to settle on account of the troublesome agitation.

Under the most favorable conditions, with a perfectly broken mixture of copper and rock assaying about 15 per cent copper, the size of particles of both materials ranging from 0.06 in. to 0.001 in. diameter, the lowest proportion of copper in the tailings ever obtained was about 4 per cent. This poor showing cannot be accounted for by the presence of any great amount of extremely fine copper, for in perfectly still water only a few seconds were required for complete settling of the mixture.

Although the cost of power alone might seem a sufficient reason for abandoning the above scheme without a trial, the author is sure that in the absence of certain unforeseen drawbacks the cost of power would not be prohibitive. The chief trouble is the agitation of the liquid, especially the local agitation in the neighborhood of each suspended particle. Since the current does not pass through the particle there is a little space immediately ahead of and behind such particles in the direction of flow of current in which no current flows. The liquid in these spaces has only ordinary weight with the result that an eddy is formed which tumbles the particles around in an irregular manner.

### Saturday Session.

### Electrical Nature of Chemical Energy.

A paper by Dr. A. H. PATTERSON, of the University of North Carolina, referred to the recent paper of Dr. J. E. Mills on the nature and source of chemical energy (our Vol. VI, p. 489). He first sketched briefly the electronic theory according to which atoms are charged or combined with positive or negative electrons. Combination ensues when two or more atoms, carrying unlike charges and coming near enough for the purpose, are pulled closely together by the electrostatic lines of force between their charges and held together tightly in a molecule.

In the case of the formation of water $H + H + O = H_2O$, each of the hydrogen atoms carries one positive electron charge and the oxygen atom two negative electron charges. Dr. Patterson calculates the amount of energy which these charged

atoms represent. The value which he finds by calculation is quite sufficient to account for the heat actually given out in the formation of water and is, moreover, of about the magnitude to be expected. Dr. Patterson thinks, however, that too much importance should not be given to his numerical result.

The hydrogen and oxygen atoms (in a molecule of water) may be considered as coming quite near each other when in combination, near enough to render the molecule electrically neutral, but not near enough to equalize the charges and not near enough to prevent stray lines of force producing a "residual attraction" between the molecules.

Dr. Mills in his paper says: "It is possible that the molecular attraction is merely the residual chemical attraction." The electrical theory would simply substitute the word "electrical" for the word "chemical" above. Dr. Patterson discusses the residual attraction somewhat further, and then speaks of electrical conduction in general, pointing out the fact that "physicists and chemists, reasoning from different viewpoints, often reach practically the same general conclusions, and further that the electrical theory, in spite of certain artificial features, seems to offer the best and clearest idea of the source of chemical energy, the mechanism of chemical combination, ionization, dissociation, etc., and the most rational explanation of the various phenomena of physical science."

The paper was briefly discussed by Dr. Gustavus Hinrichs, who spoke of the relation of the newer theories to older ones and confronted the electronic theory of matter with the chemical idea that matter is finally composed of one single substance.

### Alloys of Iron with Arsenic and Bismuth.

A paper by Prof. CHARLES F. BURGESS and JAMES ASTON, of the University of Wisconsin, gives an account of an investigation of alloys of pure iron (free from carbon) with arsenic and bismuth. This is part of the extended researches which are being carried out at the University of Wisconsin with iron alloys, made from pure electrolytic iron free from carbon.

It has been noted that the presence of arsenic in acid pickling solutions causes a marked diminution in the rate of attack by the acid, and the idea was suggested that if the presence of arsenic in a corrosive solution protected iron from corrosion by that solution, that the presence of arsenic in the iron itself might increase its durability. To test this possibility, such alloys were made, but they failed to show any marked advantage over iron and steel of ordinary grades in their ability to resist corrosion. From the arsenic alloys prepared primarily for this purpose, test bars were made and subjected to various physical tests.

In determining the magnetic properties of the arsenic alloys, some interesting and unexpected results were obtained, which in turn suggested the advisability of testing the influence of the analogous elements, antimony and bismuth, upon the magnetic quality of iron.

Arsenic, with a temperature of sublimation of 450 deg. C., alloys with iron under conditions where it has passed this temperature long before the fusion of the iron, in practically the proportions of the solid mixtures up to a content of arsenic of 4 per cent. The authors also note the interesting feature that the presence of this large quantity of an element (which when present above 0.25 per cent is most detrimental in its physical effects) imparts to the alloy magnetic qualities excelling those of the purest iron and on a par with the best material on record.

Alloys of antimony with iron seem of little value, forming a difficultly workable product with no apparent value as a magnetic material.

Alloys of bismuth with iron were made with a bismuth content of 1, 2, 4, 6 and 10 per cent and magnetic tests were made. For all tests the curves for a bismuth content of 1.0, 4.0, 6.0 and 10.0 per cent present no features of particular interest, the quality being well below the standard electrolytic iron sample. But for the bismuth content of 2 per cent the curve, while be-

low the standard for values of H of less than 22, at this point crosses the electrolytic iron curve and reaches values of density from 4 to 5 per cent higher throughout the rest of the range.

This series, therefore, presents the somewhat paradoxical condition of the addition of 2 per cent of bismuth, the most diamagnetic element known, improving the already high quality of the pure iron.

The authors refer to the difficulties of making comparisons of magnetic tests with the results of others. Magnetic testing is not on such a basis that data from various sources can be assumed as absolute, and on this account comparisons are apt to be misleading. Finally, they make some remarks on hysteresis tests and electric resistivity measurements.

### Bakelite for Chemical and Electrical Purposes.

Dr. L. H. BAEKELAND presented an elaborate paper on bakelite, containing a great many new points and supplementary to his former paper read before the American Chemical Society and published in our March issue, page 111.

In his former paper he had shown how bakelite C, or the final product, which is a polymerized compound anhydride of a
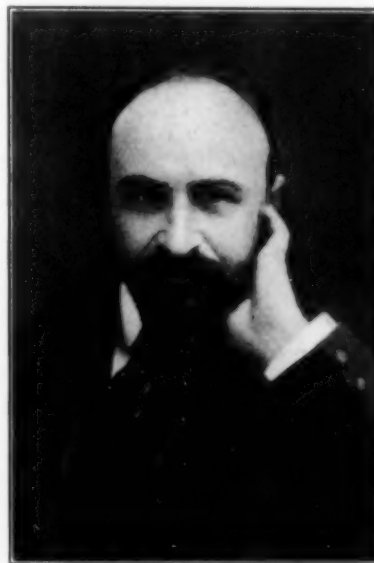


PRESIDENT-ELECT L. H. BAEKELAND.

phenol-alcohol and methylenglycol, can be produced through indirect synthesis by the action of oxybenzyl alcohol on formaldehyde as well as by direct action of phenols on formaldehyde. The latter method is the more available one for practical purposes and consists in heating, under proper conditions, a mixture of phenols and formaldehyde in presence of a catalytic agent, preferably small amounts of bases or alkaline substances. According to the conditions of operation, the process is carried out in three phases, designated by A, B and C.

A is the "initial product of condensation," produced by elimination of water, and contains probably one or more hydroxyl groups in its molecule.

B is the so-called "intermediate condensation product," a higher anhydride evolved by further elimination of water. C is the polymer of B.

Bakelite C is a hard structureless mass, which may be prepared in transparent or in opaque condition. Its color varies from that of colorless glass to amber color or dark ruby-brown. It is harder than shellac, hard rubber or celluloid, but misses the flexibility of the two latter substances, and this is the main defect.

On the other hand, it withstands all solvents and most chemicals, resists boiling water, steam and superheated steam and oils. Heating does not melt it, nor even soften it to any serious extent. Boiling concentrated sulphuric acid destroys it, so does

concentrated nitric acid, but it withstands dilute sulphuric acid, hydrochloric acid and chlorine.

It can stand temperatures of 300° C. and over. At the temperature of melting glass it chars and carbonizes without entering into fusion. In its final condition it can be sawed, cut, bored and turned on the lathe, but it can no longer be molded for practical purposes. In other words, when it has acquired condition C it is no longer a true plastic, so that all operations of molding or shaping must preferably be carried out in its earlier stages, as described in the former paper in our March issue. In its final stage it is tasteless and odorless and an excellent insulator of heat and electricity.

In cost of production it can very advantageously compete with any known plastic.

For all practical purposes A is used as raw material to start with. The latter is obtained in four varieties, each of which may be preferable according to the special purpose in view. They are: "extra thin liquid A," "liquid A," "dissolved A" and "solid A."

In the different modifications of the bakelite process the aim in view is to produce the final product C, but in as far as C is no longer plastic, all forming, shaping, molding or mixing is carried out in the earlier stages.

This is accomplished either by transforming directly A into C in one single operation, or in other cases, especially in rapid molding processes, it is found more convenient to change A into B, then remove B from the mold and afterward change it into C without the use of a mold. In some other cases the molding or shaping process is started from B and the latter is then changed into C by application of the heat.

Whether stage C is arrived at directly from A or indirectly from B, the quickest result and the best product is obtained by heating at relatively high temperatures, say, 160° C. or over. But as at temperatures above 100° C. A dissociates into gaseous products and causes the resulting mass to be porous and spongy, it is necessary to heat under pressure. Without this precaution the resulting mass will be technically worthless.
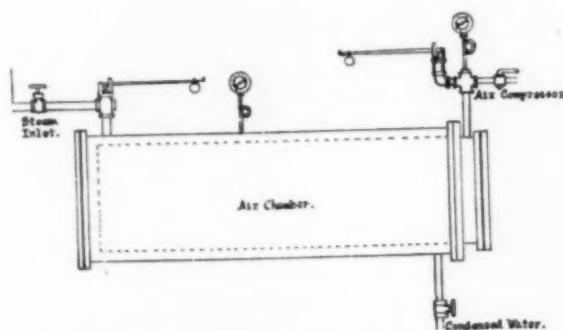


DIAGRAM OF BAKELIZER.

If the heating occurs in closed molds or closed vessels, the so developed internal pressure may be sufficient to counteract the chemical dissociation which causes porosity.

In all other cases the heating should be conducted in a so-called bakelizer, as shown in the adjoining illustration.

This is an apparatus consisting essentially of an inner chamber where the objects are placed and in which, by means of a suitable pump, air can be compressed to 100 lb. or 120 lb. This pressure is maintained during the heating. A steam jacket heats the chamber to a temperature of 140° C. to 180° C., equivalent to about 54 lb. to 150 lb. of steam.

The higher the temperature, the shorter will be the bakelizing process, which converts everything into C.

The different applications of bakelite can be divided summarily into block-working processes, impregnating processes, coating processes and molding processes.

**Block Working.**—One of the varieties of A may be simply poured into a mold and melted, or first mixed with pigments, colors or some suitable filling material, like asbestos, clay, mica,

wood pulp, graphite, etc. By heating the mass at 140° C. to 180° C. under suitably increased pressure for one to three hours, the whole solidifies to a solid block, which has the exact shape of the container and can easily be removed therefrom because there is a slight shrinkage. If organic fillers are used which are destroyed by too high temperatures, as, for instance, wood-pulp, then the minimum temperatures must be preferred and the time of heating must be increased accordingly. No such restrictions exist for mineral fillers. The so-obtained blocks can now be sawed, cut, turned, polished and shaped in about the same way as ivory or bone is handled.

For large blocks it is preferable to simply continue the heating until stage B is reached and then cut the latter to the proper shape; then B is submitted to further action of heat until it is changed into C.

B, while slightly warm, is soft and somewhat elastic and cuts about as easily as Swiss cheese, yet if heated further it does not liquify nor change its original shape. The transformation of A into B does not need to be carried out under pressure. It may be accomplished simply by heating for a few hours, at temperatures not exceeding 70° C., any of the varieties of A, either in an air-stove or in a water bath.

In order to change B into C it can be heated to proper temperature in a bakelizer as described above. B is no longer attacked by hot water as A is, and for that reason it may be simply heated in an ordinary autoclave containing water in about the same way as rubber is vulcanized for dental purposes, with this difference, however, that higher temperatures should be used than are permissible in the rubber process.

Molds are here entirely superfluous and the objects so treated will retain perfectly their shape. Temperatures of 160° C to 170° C. are quite suitable, but Dr. Baekeland has used with impunity temperatures as high as 200° C. and over.

**Impregnating Processes.**—Liquid A in its extra thin variety is readily absorbed by any porous materials. If a piece of non-resinous soft wood, like basswood or poplar wood, be immersed in extra thin liquid A, after a few hours it will be found that the wood has doubled or even tripled its former weight. The same treatment can be given to unsized paper, paper pulp, cardboard, asbestos, objects of cement or plaster of paris, in fact, to any material of a fibrous, cellular or otherwise porous texture. The imprégnated material is now transferred to the bakelizer and submitted there to final treatment. But longer heating is required than under ordinary conditions.

In most instances the impregnated objects have a dull appearance on the surface. This can be easily remedied by applying a second superficial coat of thicker A. The latter is best applied while the objects are still hot; this treatment will impart a very hard and a very glossy surface.

Wood thus treated is not only much harder and stronger, but it has become rot proof, and is a better electrical insulator. It withstands dilute acid solutions and ordinary electrolytes. It can be used to excellent advantage for third-rail covers. Similar usages can be found for impregnated pulp-board, cardboard and asbestos-board.

For the impregnation of **coils for dynamos,** motors and transformers, bakelite represents a ready means to provide these apparatus with a hard and strong insulating mass which cannot soften under the influence of heat, and which withstands temperatures at which all hitherto used gums or resins would melt away.

By the synthesis of bakelite, a certain amount of water is set free and this water must be eliminated from the coils by after-drying. Furthermore, bakelite in its final state C, although very hard and tough, is not flexible; so that any wires or conductors coated with it can no longer stand much bending or twisting, and for such parts the bakelizing operation should only take place after all wires and conductors are in their final place.

With this aim in view, the wire or conductor, provided with its covering of cotton or asbestos, can be simply coated

with dissolved A solution properly diluted with the necessary amount of alcohol, then submitted to spontaneous drying. This may be helped by a gentle application of heat, but never more than is necessary to carry the material to the stage B, so as to maintain the necessary flexibility. The wire is now wound as usual, and in order to insure more flexibility it may be found useful to heat it slightly. Tape or any fabric, or asbestos impregnated with A, may be put between successive layers just as is done when shellac is used as an insulator; after the coil is made up it is now introduced into the bakelizer.

In case the wires are covered exclusively with asbestos it will be advantageous to heat the bakelizer at highest temperatures. However, if cotton or similar organic materials be present, such high temperatures would destroy and carbonize them and it may be safer not to exceed 140° C. After bakelizing, the coils should be submitted to slow drying so as to expel any remaining traces of moisture or solvents, and this operation can be hastened considerably by the use of a vacuum dryer.

In other cases ready-wound coils may be simply impregnated with liquid A, using the precautions as described for the impregnation of wood. Capillary conditions as described for the wood-impregnating process exist here, so that, with some precaution, it is possible to slowly transform A into C or at least into B in an ordinary drying stove, without the absolute necessity of resorting to a bakelizer, always provided the heating be started at temperatures as low as 60° C. to 70° C. and gradually increased to 120° C. to 140° C. In fact, it may be found sufficient not to go beyond B and leave it to future self-heating of the wire when run under overload to arrive at the final condition, C.

As a modification to above methods, the following is suggested: The coil after being properly impregnated may simply be put in an accurately made closed mold and the latter may be filled with more A, using pressure as required, so that after bakelizing same the whole will come out in accurate size and shape and present a much neater appearance than the ordinary clumsy coils now in use for dynamo and motor construction. The very fact that henceforth it is possible to mold coils in regular shapes and most accurate dimensions may ultimately simplify the construction of this class of machinery and render renewals much easier.

**Coating Processes.**—The simplest way for coating an object with bakelite is to dip it in liquid A and then finish it in the bakelizer. By slightly heating the objects and by using rather thick A the operation becomes rather simple, especially for metallic objects.

Or the A-coated objects may be first heated gently in a stove until the A has been transformed into B and then the object may be transferred to the bakelizer. Several coats may thus be applied in succession until any desired thickness is attained.

Suitable filling materials, as silica or fine sand, clay, slate dust, powdered asbestos, etc., added to liquid A in suitable proportion, will give a putty-like mass which can be easily kneaded, especially if slightly heated; it can be applied and modeled to any kind of surface to the desired thickness and shape.

This same mass can be rolled out in thin sheets and the latter can be applied on the inside or outside of metallic vessels. The whole can be directly finished in the bakelizer or be heated previous at low temperatures so as to bring it first into B state.

This method gives a ready means for covering iron pipe or pumps or similar objects with a layer of protective material and thus render them more suitable for chemical engineering purposes.

Thick layers of bakelite without fillers or mixtures containing little filler do not adhere well to metallic surfaces. But by using more filler and specially by using gritty materials, as fillers, like sand or abrasives, the adherence becomes excellent. For instance, mixtures of emery with about 10 to 15

per cent liquid A, can be made so that after bakelizing they will stick to glass to the point that they can no longer be removed unless by chipping off pieces of glass.

A composite coating of bakelite can also be applied on wooden or metallic vessels by first dipping a sheet of asbestos in A, partially transform it into B by heating, then stick it, by means of thick A, to the surface which is intended to be protected, and afterward press it against the surface by means of a hot, smooth plate. The latter operation is finished in about 10 to 15 minutes if the pressing plate is maintained sufficiently hot. By selecting polished metallic pressing plates a very beautiful finish can be obtained at the same time. In this case bakelite not only acts as an impregnating and finishing material, but also as an excellent and permanent adhesive.

A similar method may become useful for lining wooden or metallic boxes with impregnated asbestos so as to make them suitable for electrolizing tanks or storage batteries.

Sheet-iron or stamped boxes provided with a thin coating of bakelite can stand boiling dilute sulphuric acids and boiling neutral solvents.

It should be borne in mind that on account of the limited flexibility of bakelite, such sheets cannot be twisted or bent beyond certain limits without splitting the protective layer. In any such cases where bending has to be done, it must be done before the varnish is applied or after the A has been changed into B, which still leaves some scope for flexibility.

**Molding Processes.**—The simplest but slowest way for molding bakelite is to pour liquid A, alone or mixed with filler, into suitable molds and heat in a bakelizer. This operation may take as much as one to three hours, according to the temperature or to the size of the object, so that this process has the objection of requiring the relatively long use of molds.

It can be shortened by simply carrying the heating process until the B stage, after which the objects can be expelled from the molds and finished in the bakelizer at any suitable time thereafter and without the further use of molds. The B stage can be obtained by plain, but slow heating in a stove or water bath, or by rapid heating in the bakelizer.

But even all this is too slow for many purposes where quick and accurate molding is essential. It then becomes simpler to mold in a hot press. For this purpose a hydraulic press or a screw press or even a lever press can be used, as long as it is provided with contrivances whereby the plateens can be heated and cooled quickly, either by steam and cold-water circulation, or by gas heating.

Temperatures as high as 200° C. are desirable for rapid and best work, but the molding can be done also at 80-lb. steam pressure. It is a noteworthy fact that molds under high-pressure contact with the plateen heat up and cool quicker than if not under pressure.

The great penetrating power of A makes it possible of making molded objects containing as little as 10 per cent and even less of bakelite, the remainder being made up of suitable fillers, for instance, asbestos. Quantities of 20 to 30 per cent of solid A and 80 to 70 per cent of asbestos make excellent compositions for molded insulators.

In some cases it may be found desirable to increase the amount to about 40 per cent. Wood pulp or ground sawdust requires these larger proportions if the objects have to stand boiling water without losing their gloss.

Molded objects of bakelite in B condition are about as strong as shellac, but they still soften under the influence of heat. They become considerably stronger and acquire their final resistance qualities by being heated in the bakelizer. There is again a slight shrinkage of volume which has to be taken into consideration while designing the molds. This contraction is always the same for the same compositions, and becomes very small if large amounts of fillers are used. By taking these factors into consideration the molding can be done with an accuracy of 0.001 in. or better.

B, although infusible and insoluble, softens when heated

under high pressure and welds and molds together. This enables to still further simplify the molding operation by using ground B instead of A. But it then becomes necessary to use maximum temperatures and highest possible pressure, B not flowing so easily as A. This is specially indispensable when large amounts of filling material are employed. This method of working is decidedly advantageous when a highly polished surface and very accurate molding are desired. By keeping long enough in the mold no after-treatment in the bakelizer is required, and the gloss imparted by a polished mold is thus kept intact. The use of B is also advisable in such instances where mixtures rich in bakelite are desired.

For such molded electric insulators which are expected to stand high temperatures, finely ground asbestos, clay, mica or other similar fillers should be used. Whether bakelite-asbestos or bakelite-mica insulators will answer the purpose for high-voltage insulation as well or worse than porcelain is a matter which experience and the test of time can alone decide.

For insulation in third-rail systems, where continuous vibration of passing trains plays havoc with brittle and unreliable porcelain, bakelite-asbestos has indicated decided superiority after several months of continuous service, as well as by direct laboratory tests; besides greater strength, it has shown more regularity in manufacture and allows more accurate molding, which permits closer designs and smaller margin of safety.

Dr. Baekeland gives in several tables the results of electrical, mechanical and heat tests to prove a decided superiority of bakelite over some excellent insulating compounds.

Dr. Baekeland finally mentions the special mixture of bakelite with graphite. These two materials compound very well together in almost any proportions. Liquid A or solid A can be used for this purpose. By varying the amounts of bakelite these compositions may be made of varying hardness.

He has obtained some very encouraging results by trying to use them for self-lubricating bearings. The fact that such bearings can be molded very accurately at little cost makes their interchangeability and rapid renewal a very easy matter. Dynamos or motors or other revolving machinery where lubrication is a delicate matter might be provided with such bearings instead of the older metallic bearings. Bakelite-graphite bearings will not melt nor soften in case of overheating; they can be used in conjunction with oil like any other bearings, and in case of insufficient supply of oil the graphite present will supply the necessary lubricant.

As a lining for pumps which are required to handle liquids which corrode iron the same mass may find its uses.

But bakelite-graphite composition presents other possibilities from an electrical standpoint, since it gives a means of producing a material of which the electrical resistance can be changed at will in a very wide range by changing the proportion of bakelite.

### Graphite Cathode Dish.

In a paper by Dr. J. W. TURRENTINE, of the Wesleyan University, simple graphite electrodes (paraffined, to overcome the porosity) are described which are designed for use in the place of platinum as insoluble electrodes in electrochemical experiments.

An account is also given of preliminary experiments with a graphite dish intended to supplant in some forms of electrochemical analysis the Classen platinum dish. The dish is recommended for electrochemical separations and for analysis where great accuracy is not required. Confidence is felt that, after it has been further developed, it will be able to entirely take the place of the platinum cathode dish. Details are given of the method of preparation.

### Gas Coulometer.

A paper by Dr. J. W. TURRENTINE describes a modified oxy-hydrogen gas coulometer. It is a modification of the Walter-Neumann single-tube coulometer. The latter is provided with a leveling bulb, and therefore becomes a direct-reading instru-

ment. This form is especially convenient for all current efficiency experiments when the electrode products are wholly, or in part, gaseous. The leveling bulb makes it possible to read the gas volumes which are to be compared at atmospheric pressure.

The Walter-Neumann coulometer is constructed of a single, upright tube, graduated, with an oblong, bulbous enlargement at its lower end, containing the electrodes, and is surmounted on its upper end by a stop-cock and capillary tube. The lower end is joined by means of a length of rubber tubing to a level-
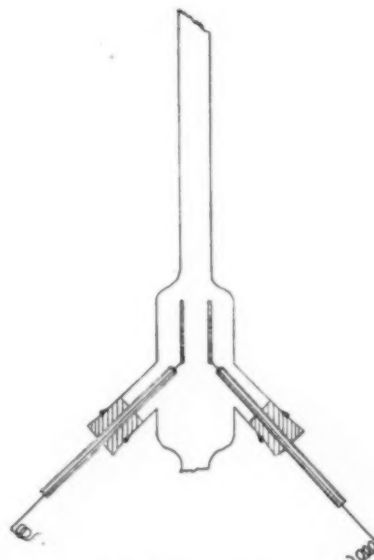


GAS COULOMETER.

ing bulb. The electrodes are corrugated plates of platinum foil mounted on thin platinum wires, the latter being sealed through the walls of the bulb, and terminated on the outside in small tight coils or loops. Electrical connection is made with the electrodes by hooking wires in these external loops.

The disadvantages of this apparatus are due to the fragility of the terminal wires and the glass seal which holds them. The platinum terminal wires, being thin, are easily bent, and, in spite of care, are soon broken off. This renders the apparatus useless. Further, only poor contact is gotten with the terminal loops by hooking wires in them, yet this is the only means that may be employed for completing the electrical connection. If wires are fastened more securely in the coils, the latter are almost immediately broken off. The poor connections, with resulting imperfect contacts, cause the glass to crack and the tube to leak.

In the modification of Dr. Turrentine the upper part of the Walter-Neumann apparatus is modified only in small details, but the lower, bulbous portion of the main tube has been greatly changed. This bulb is oblong and is $3\frac{1}{2}$ in. in diameter. Instead of the two platinum wires it now carries, sealed in its walls, two side arms, or tubes, opposite each other and at an angle of $45°$ to the perpendicular or longitudinal axis of the tube. They are made to slope downward at this angle so that gas bubbles, carried into them by connection currents, cannot become lodged. The side arms are made of thin platinum foil and are deeply corrugated to enlarge their surface. They are $1\frac{1}{4}$ in. x $1\frac{1}{2}$ in. in dimensions and afford an electrode surface of at least 1 sq. in. on each face. Supporting them is a short section of platinum wire, which is sealed in a length of glass tubing of $1/5$ in. external diameter and 3 in. long, and which is welded to a piece of insulated copper wire about 1 ft. in length and extending through the tube. The glass tubes are inserted through one-holed rubber stoppers, which fit the side arms.

The construction renders the electrode easily detachable. This is especially desirable when they need cleaning. As the

electrodes are not subjected to much wear, they should have a long life.

### Calcium Carbide.

A paper by Profs. S. A. Tucker, W. A. Alexander and H. K. Hudson, of Columbia University, compares the relative efficiency of the arc and resistance furnace for the manufacture of calcium carbide. Theoretically the advantage of the resistance furnace is that the temperature can be regulated and held at a point much below that of the arc. Experiments were made on a small scale in the laboratory and the results are summed up as follows:

In all respects the resistance method is the most efficient. On the average the resistance method was about three times as efficient as the arc method, while the best run of the resistance method was twice as efficient as the best run of the arc method.

In both methods the quality of the yield was mainly influenced by the proportion of coke and lime used in the charge. In the arc method, the best carbide was obtained with a charge of 55 per cent coke and 45 per cent lime. In the resistance method, the best carbide was obtained with a charge of 50 per cent coke and 50 per cent lime.

The time of run influenced the quantity of the yield, but after eight to nine minutes in the arc method and 20 to 22 minutes in the resistance method, under the conditions of the experiments, the increase in the yield was not proportional to the increase in length of run.

The value of the current used in the resistance method influenced the quality of the yield. If the current was too high the carbide was burned, due to excessive heat. In the resistance method the best part of the carbide was found at the bottom of the furnace, while the part directly between the electrodes was somewhat burned. This was due to the fact that the main part of the current passed through this part of the charge and the temperature reached was above that necessary for the formation of calcium carbide. In the arc method the best of the carbide was found at the bottom of the crucible.

An analysis showed that about 20 per cent of the original coke in the charge was burned out of the unconverted charge in the resistance method.

### Silicon.

A paper by Mr. C. I. Zimmerman, of the University of Wisconsin, is a very useful summary of our present knowledge of the physical properties of crystalline silicon. Concise data are given of atomic weight, specific gravity, molecular state of aggregation, tenacity, expansion with temperature, tensile strength, hardness, porosity, melting point, vapor tension, specific heat, latent heat of fusion, heat of combustion, thermal conductivity, optical properties, spectrum, magnetic properties, electrical properties, thermo-electric properties, rectifying properties, Hall effect and electrical resistance. As this paper itself is a summary, it is impossible to abstract it briefly.

### Calcium Alloys as Reducing Agents.

A paper by Dr. O. P. Watts and E. R. Suhm, of the University of Wisconsin, describes a continuation of the research recorded in our Vol. 6, page 237. On account of the greater reducing action of calcium-magnesium alloys in comparison with aluminum, it had been hoped that it would be possible to obtain fused tungsten and titanium as reduction products. These hopes were not realized.

One of the chief difficulties is the violence of the reaction with calcium-magnesium alloys. This may be effectively overcome by molding a charge of very finely pulverized material into briquets.

It was further found necessary to devise some means of heating the charge considerably above the temperature at which reaction begins, in order that the heat added by the reaction should produce a fluid slag and a good separation of metal. A number of experiments made are described and the results are summed up as follows:

The direct comparison of aluminum with calcium-magnesium

aluminum alloys as reducing agents gave conflicting results. In the reduction of a mixture of $MnO_2$ and $TiO_2$ aluminum was superior, while in reducing $Mn_3O_4$ the alloy gave far better results. It is probable that the alloys are superior in all cases where none of the charge is blown out of the crucible. The alloys are distinctly superior to aluminum for the igniting mixture.

As noted above, attempts were made to supply enough heat to secure solid masses of tungsten and titanium, either by rapidly heating a charged crucible in a resistance furnace, or by heating with an arc of 50-60 kw, or by feeding the charge into a mass of melted oxides, or by adding $BaO_2$ and extra alloys to the charge. But all these methods failed.

The vaporization of $MoO_2$ can be prevented by getting it into combination with other oxides before an extremely high temperature is attained.

Since the violence of reaction of the alloys increases with the amounts of calcium and magnesium, the most serviceable as well as the cheapest alloys will probably be those with only enough calcium or magnesium to be readily pulverized.

### Protection of Steel Against Corrosion.

A paper by Mr. Maximilian Toch emphasizes that oxidation cannot take place, under any circumstances, in the absence of moisture, as the addition of water is a necessary element in the composition of ferric hydroxide, hence the necessity to coat steel which is surrounded by either ordinary fireproof masonry or embedded in concrete, with a material which shall have electric insulating qualities and moisture-resisting qualities, rather than inhibitive qualities for the inhibition is merely secondary and the primary cause of the corrosive effect is water itself.

Much is said of the protective quality of concrete, but concrete as it is generally used contains rarely more than 15 per cent of cement, and cement is the real protective agent in the prevention of corrosion. The concrete mixture is either composed of 1:2:4 or 1:3:5, the third number representing the aggregate, which is largely composed of broken stone. The physical characteristics of the materials used preclude the possibility of a dense concrete, and the voids which are adjacent to the steel itself are largely the cause of rust-producing agents.

A perfect coating of insulating material should be given the steel, rather than a perfect coating of such paint as shall itself be affected by moisture and be decomposed by moderate alkalies. It is necessary to use alkali-proof material. A carbon-black paint when mixed with linseed oil forms practically no protection for steel which is to be surrounded by alkaline and wet masonry of any kind. If a beam is coated with linseed-oil paint and then covered with an inch of cement mortar, a driving rain will go through such a wall and carry with it sufficient solvent salts to disintegrate the paint and leave a space between the steel and the concrete, and once corrosion starts in a place of this kind, it will proceed.

### Rapid Electrochemical Analysis.

In a paper by Messrs. L. S. Palmer and R. C. Palmer, of the University of Missouri, reference is made to the various devices which have been employed in recent years for rapid electro-analysis, such as rotating the cathode, rotating the anode, and lately even rotating the electrolyte. Some experiments on the determination of copper with the apparatus of Frary (Jour., Am. Chem. Soc'y, Vol. 29, page 1592, 1907), in which the electrolyte is rotated and the electrodes are stationary, led the present authors to believe that the speed with which complete deposition was obtained was not wholly accounted for by the fact that the electrolyte rotated, but depended to a large extent upon the nature of the electrodes. The anode used in the Frary apparatus is a platinum spiral of about 1 mm diameter; the cathode a platinum gauze, weight about 14 grams, 15 mesh to 1 cm, size 11 cm x 5 cm.

To test this supposition the present authors conducted a

series of tests to determine the relative merits of the two factors—gauze cathode and rotating electrolyte in rapid depositions. Three comparative sets of tests were, therefore, made: one with a rotating electrolyte using the gauze cathode; a second set without rotation of electrolyte using a gauze cathode, and for comparison a series using the usual form of platinum cone as cathode, without rotation of the electrolyte.

In one of the most interesting runs 0.31 gram of copper was completely deposited on the gauze cathode in 25 minutes with magnetic rotation of the electrolyte, in 50 minutes without rotation, and in five hours using the platinum-cone cathode. It seems from this that the rapidity of Frary's method is due, in a large measure, to the gauze cathode.

The conclusion of the authors is that the efficiency of the gauze cathode, thus shown, warrants its use alone for simple, rapid determinations, thus dispensing with the various mechanical devices for agitation of the electrolyte.

### Soil Analysis.

A paper by Dr. F. K. CAMERON, of the Departmen of Agriculture, Washington, discussed electrochemical methods of soil analysis. He suggested that the greatest weathering agent in nature is plain solution in water. His methods of analysis is essentially a measurement of resistance by a Wheatstone-bridge method.

### Corrosion.

A brief paper, by Mr. WM. ROY MOTT, of the University of Wisconsin, discussed the "overvoltage" as a factor in the corrosion of metals. Hydrogen requires different voltages for its separation on different electrodes and on this, in part, depends the amount of local current that flows in the corrosion of metals. Some old data on the corrosion of zinc is shown to be qualitatively and quantitatively explained by observed data on overvoltage.

### Tubular Conductors.

The last paper of the meeting was presented by Mr. C. I. ZIMMERMAN on concentric tubular conductors for heavy currents, instead of busbars. He suggested the use of concentric conducting tubes, the inner shell of the inner tube and the outer shell of the outer tube to be water-cooled.

Mr. Carl Hering then moved a vote of thanks to the local committee and all who had contributed to the success of the meeting. The convention then adjourned, Dr. Baekeland as the new president making a felicitous little speech.

The next meeting wil be held in October in New York.

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All the weekly technical papers interested in the fields covered by the American Electrochemical Society have already published extended and highly appreciative reports on the meeting, especially *Electrical World*, *Electrical Review and Western Electrician*, and *Iron Age*. But the most interesting remarks appeared probably in *The Iron Trade Review*, of Cleveland, who published not only an editorial on the "significance of a successful convention," with special reference to the symposium of papers on the electrometallurgy of iron and steel, but also another editorial entitled "The Decadence of Some Technical Societies," beginning as follows: "There have been numerous references of late to the ossification which seems to set in with certain old-established societies formed in the first instance for the interchange and dissemination of technical knowledge." Specific reference is then made to the recent Washington meeting of a large engineering society of this country. The editorial concludes as follows: "In striking contrast with the Washington meeting was that of the younger organization, the American Electrochemical Society." . . . . "Another organization which always does good work at its meetings is the American Society for Testing Materials. Both of these societies are fortunate in having able and wise presidents and secretaries."

In the following we give a complete alphabetical list of all the members and guests who registered at the meeting:

Dr. and Mrs. Ed. G. Acheson, Niagara Falls, Ont.; Edward G. Acheson, Jr., Niagara Falls, N. Y.; R. W. Acheson, Niagara Falls, N. Y.; Chas. E. Acker, New York City; R. C. Acott, Niagara Falls, N. Y.; A. F. Ahlbrandt, Middletown, Ohio; H. G. Akers, Toronto, Canada; F. Albright, Buffalo, N. Y.; Thos. B. Allen, Niagara Falls, N. Y.; Mr. and Mrs. W. H. Arison, Niagara Falls, N. Y.; Miss Arison, Niagara Falls, N. Y.; H. L. Arnold, Pittsburg, Pa.; James Aston, Madison, Wis.; L. H. Baekeland, Yonkers, N. Y.; J. Watson Bain, Toronto, Canada; F. H. Banbury, Niagara Falls, N. Y.; Wilder D. Bancroft, Ithaca, N. Y.; W. P. Barba, Philadelphia, Pa.; George T. Barker, Niagara Falls, N. Y.; J. B. Barned, New York City; A. Barton, Toronto, Ont.; Mr. and Mrs. P. P. Barton, Niagara Falls, N. Y.; Joseph F. Becker, Brooklyn, N. Y.; Fred M. Becket, Niagara Falls, N. Y.; John W. Beckman, Niagara Falls, Canada; Howard C. Beltz, Hornell, N. J.; P. McN. Bennie, Niagara Falls, N. Y.; S. D. Benoliel, Philadelphia, Pa.; E. R. Berry, Boston, Mass.; E. Blough, Pittsburg, Pa.; H. A. Boyd, Buffalo, N. Y.; Wm. Brady, S. Chicago, Ill.; Harry L. Brinker, Youngstown, Ohio; J. W. Brown, Cleveland, Ohio; C. F. Burgess, Madison, Wis.; E. C. Butler, Niagara Falls, N. Y.; J. R. Cain, Washington, D. C.; G. H. Calkins, Buffalo, N. Y.; F. D. Carney, Steelton, Pa.; C. F. Carrier, Jr., Elmira, N. Y.; E. B. Carter; Hector R. Carveth, Niagara Falls, N. Y.; C. R. Cary, Philadelphia, Pa.; Adolph Chalas, Paris, France; D. H. Childs, Niagara Falls, N. Y.; Camillo C. Cito, Givington, N. J.; R. H. Clayton, Manchester, England; W. F. Clymer, Cleveland, Ohio; Jesse Coates, Coatesville, Pa.; Frank N. Coe, Niagara Falls, N. Y.; H. B. Coho, New York City; Edward A. Colby, Newark, N. J.; E. P. Coleman, Buffalo, N. Y.; W. P. Colire, Toronto, Ont.; Charles Colne, New York City; V. G. Converse, Niagara Falls, Canada; Mr. and Mrs. H. J. Corvil, Niagara Falls, Ont.; L. B. Coulter, Niagara Falls, N. Y.; Mr. and Mrs. Alfred H. Cowles, Lockport, N. Y.; G. E. Cox, Niagara Falls, N. Y.; Fred. Crabtree, Pittsburg, Pa.; W. N. Crafts, Cleveland, Ohio; Chas. Crew, New York City; H. C. Cridland, Dayton, Ohio; R. Cuchens, Niagara Falls, N. Y.; F. M. de Beers, Chicago, Ill.; E. L. Diehl, Pittsburg, Pa.; H. H. Doro, Midland, Mich.; E. L. Doty, Buffalo, N. Y.; J. C. Downs, Niagara Falls, N. Y.; Hugo Du Bois, New York City; W. L. Dudley, Nashville, Tenn.; O. E. Dunlap, Niagara Falls, N. Y.; Mr. and Mrs. F. I. du Pont, Wilmington, Del.; Mr. and Mrs. Irene du Pont, Wilmington, Del.; J. A. Durfee, Chardon, Ohio; S. Dushman, Toronto, Canada; I. R. Edmands, New York City; Theo. W. Elliott, Mr. and Mrs. J. W. Evans, Belleville, Ont.; E. S. W. Farnham, Philadelphia, Pa.; F. A. J. FitzGerald, Niagara Falls, N. Y.; Chas. E. Foster, Rochester, N. Y.; R. E. Fowler, Niagara Falls, N. Y.; Dr. K. C. Frank, New York City; Eugene Friedlaender, Braddock, Pa.; G. C. Furness, Niagara Falls, N. Y.; Radclyffe Furness, Philadelphia, Pa.; E. T. Gehckens, Pittsfield, Mass.; Mr. and Mrs. W. T. Gibbs, Buckingham, Ont.; Mr. and Mrs. A. E. Gibbs, Wyandotte, Mich.; Irvin K. Giles, Niagara Falls, N. Y.; D. W. Gillett, Ithaca, N. Y.; James Graham, Niagara Falls, N. Y.; Ainslie A. Gray, Chicago, Ill.; A. E. Greene, Chicago, Ill.; Leo F. Guttmann, New York City; Eugenie Haanel, Ottawa, Canada; Chas. M. Hall, Niagara Falls, N. Y.; Frank E. Hall, Kenmore, N. Y.; Samuel F. Hall, Niagara Falls, N. Y.; Carl Hambuechen, Madison, Wis.; T. J. Hancock, Chicago, Ill.; W. W. Hanlan, Granite City, Ill.; C. A. Hansen, Schenectady, N. Y.; J. L. Harper, Niagara Falls, N. Y.; William Smith Harvey, Niagara Falls, N. Y.; Mr. and Mrs. F. W. Haskell, Niagara Falls, N. Y.; John Hay, London, England; D. M. Hepburn, Niagara Falls, N. Y.; Carl Hering, Philadelphia, Pa.; Henry D. Hibbard, Plainfield, N. J.; A. C. Higgins, Worcester, Mass.; Dr. Gustavus Hindrichs, St. Louis, Mo.; S. E. Hitt, Buffalo, N. Y.; Mr. and Mrs. A. H. Hooker, Niagara Falls, N. Y.; Henry Howard, Boston, Mass.; L. E. Howard, Chicago, Ill.; G. A. Hulett, Princeton, N. J.; Mrs. M. L. Hutchinson, Cincinnati, Ohio; E. J. Hutchinson, Cincinnati, Ohio; O. S. James, Toronto, Canada; Rees James, Munhall, Pa.; D. J. Jenkins, Syracuse, N. Y.; Frederick A. Johnson, New York City; A. B. Jones, Niagara Falls, N. Y.; Phil. H. Jordan, Cleveland, Ohio; B. Katsura, Tokio, Japan; E. J. Kenny, Johnstown, Pa.; H. W. Kellogg, Niagara Falls, N. Y.; P. O. Kernery, Pittsburg, Pa.; E. D. Kingsley, New York City; C. Kirchhoff, New York City; K. Knudsen, Brooklyn, N. Y.; Wm. Koehler, Cleveland, Ohio; E. F. Lake, New York City; W. E. Lambert, Niagara Falls, N. Y.; F. M. Lane, Cleveland, Ohio; Horace W. Lash, Cleveland, Ohio; H. Hughart Laughlin, Pittsburg, Pa.; J. D. Lewis, Braddock, Pa.; F. A. Lidbury, Niagara Falls, N. Y.; A. T. Lincoln, Troy, N. Y.; E. S. Lincoln, Boston, Mass.; Mrs. E. S. Lincoln, Brookline, Mass.; Henry B. Logan, Niagara Falls, N. Y.; F. A. Luther, Hamilton, Ont., Canada; R. L. MacDonald, Niagara Falls, N. Y.; J. H. MacMahon, Niagara Falls, N. Y.; F. Maculen, Prince Bay, N. Y.; Paul R. Manahon, Boston, Mass.; Otto Mantius, Philadelphia, Pa.; A. L. Marsh, Detroit, Mich.; C. W. Marsh, Niagara Falls, N. Y.; Mr. and Mrs. J. G. Marshall, Niagara Falls, N. Y.; John A. Matthews, Syracuse, N. Y.; Max Mauran, Niagara Falls, N. Y.; A. S. McAllister, New York City; L. N. McDonald, Youngstown, Ohio; D. McIntosh, Montreal, Can.; Robert J. McNitt, Niagara Falls, N. Y.; K. J. McRae, Niagara Falls, N. Y.; Wm. F. Meredith, Niagara Falls, N. Y.; Mr. and Mrs. J. L. Merrill, Pittsburg, Pa.; E. D. Miller, Niagara Falls, N. Y.; W. Lash Miller, Toronto, Ont.; Kenneth B. Millett, New York City; Harry P. Mills, Toronto, Ont.; James W. Mills, Granite City, Ill.; H. S. Miner, Gloucester City, N. J.; Richard Moldenke, Watchung, N. J.; Mr. and Mrs. G. W. Morden, Toronto, Ont.; J. L. Morice, Niagara Falls, N. Y.; C. H. Moritz, Niagara Falls, N. Y.; Henry G. Morris, Philadelphia, Pa.; W. R. Mott, Madison, Wis.; Grant C. Moyer, Niagara Falls, N. Y.; J. M. Muir, New York City; Henry N. Muller, Pittsburg, Pa.; Wm. E. Nickerson, Boston, Mass.; Dr. and Mrs. E. F. Northrup, Philadelphia, Pa.; J. E. Ober, Pittsburg, Pa.; G. Ornstein, Niagara Falls, N. Y.; R. S. Orr, Pittsburg, Pa.; G. T. Page, Pittsburg, Pa.; C. W. Parkhurst, Johnstown, Pa.; Chas. L. Parsons, Dunham, N. H.; John C. Pennie, New York City; Napoleon Petinot, Niagara Falls, N. Y.; Ross Phillips, Niagara Falls, N. Y.; Mr. and Mrs. O. W. Pickering, Springfield, Mass.; Albert E. Playter, Toronto, Ont.; I. La Verne Powers, Niagara Falls, N. Y.; J. W. H. Randall, Niagara Falls, N. Y.; K. C. Randolf; L. V. Redman, Toronto, Ont.; John C. Reed, Steelton, Pa.; R. C. Reed; P. P. Reese, Munhall, Pa.; A. G. Reeve, Niagara Falls, N. Y.; E. N. Reilly, Jr., Niagara Falls, N. Y.; H. K. Richardson, State College, Pa.; Joseph W. Richards, South Bethlehem, Pa.; Miss Florence M. Richards, Philadelphia, Pa.; Miss M. Ellen Richards, Philadelphia, Pa.; Wm. A. Ritenburg, Niagara Falls, N. Y.; Hugh Rodman, Pittsburg, Pa.; E. F. Roeber, New York City; Ashmead G. Rogers, Niagara Falls, N. Y.; W. Ross, Lockport, N. Y.; Louis Ruhl, New York City; Henry E. K. Ruppel, Boston, Mass.; Mr. and Mrs. C. J. Russell, Philadelphia, Pa.; Pedro G. Salom, Philadelphia, Pa.; Mr. and Mrs. L. E. Saunders, Niagara Falls, N. Y.; Carl G. Schuederberg, Pittsburg, Pa.; Henry F. Schmul, New York City; Edw. J. Schneider, Niagara Falls, N. Y.; W. H. Scott, Syracuse, N. Y.; J. A. Seede, Schenectady, N. Y.; Mr. and Mrs. E. M. Sergeant, Niagara

Falls, N. Y.; Mr. and Mrs. G. W. Sergeant, Reading, Pa.; S. N. Sharples, Boston, Mass.; H. F. Sill, Pittsburgh, Pa.; A. S. Simmers, Niagara Falls, N. Y.; Louis Simpson, Ottawa, Can.; V. Skillman, Ithaca, N. Y.; Chas. V. Slocum, Pittsburg, Pa.; A. W. Smith, Cleveland, Ohio; Edmond F. Smith, Niagara Falls, N. Y.; Mr. and Mrs. Wm. A. Smith, Niagara Falls, N. Y.; Y. C. Smith, Niagara Falls, N. Y.; W. L. Spalding, Buffalo, N. Y.; Mr. and Mrs. E. C. Speiden, New York City; E. A. Sperry, New York City; Mr. and Mrs. E. C. Sprague, Niagara Falls, N. Y.; F. A. Stamps, Niagara Falls, N. Y.; A. Stansfield, Montreal, Can.; Cav. Ernesto Stassano, Turin, Italy; R. H. Stevens, Munhall, Pa.; Aug. Stillesen, Niagara Falls, Ont.; Mr. and Mrs. G. W. Stone, Niagara Falls, N. Y.; C. J. Strosacker, Midland, Mich.; Wm. Theophitus Stuart, Toronto, Canada; J. L. Stuart, Toronto, Canada; G. M. Sturgess, Buffalo, N. Y.; Dr. and Mrs. J. Takamine, New York City; Chas. E. Taylor, Penn Yan, N. Y.; Mr. and Mrs. E. R. Taylor, Penn Yan, N. Y.; Miss E. B. Taylor, Penn Yan, N. Y.; B. F. Thomas, Chattanooga, Tenn.; J. P. Tindall, Toronto, Ont.; James Tinlin, New York City; Mr. and Mrs. F. J. Tone, Niagara Falls, N. Y.; S. A. Tucker, New York City; T. E. Tynes, Buffalo, N. Y.; C. A. Tyron, Niagara Falls, N. Y.; W. H. Van Winckel, Toronto, Ont.; Mr. and Mrs. C. F. Vaugn, Niagara Falls, N. Y.; F. K. Vial, Chicago, Ill.; Anthony Victorin, New York City; Mr. and Mrs. Alois von Isakovics, Monticello, N. Y.; Mr. and Mrs. S. S. Wales, Munhall, Pa.; Walter Wallace, Niagara Falls, N. Y.; Louis E. Ward, Midland, Mich.; Tracy D. Warring, Perth Amboy, N. J.; G. B. Waterhouse, Yonkers, N. Y.; Oliver P. Watts, Madison, Wis.; F. B. Weaver, Buffalo, N. Y.; R. F. Webber, Niagara Falls, N. Y.; Fred. B. Wheeler, Syracuse, N. Y.; Mr. and Mrs. E. H. Whitlock, Cleveland, Ohio; W. R. Whitney, Schenectady, N. Y.; B. Wiley, Pittsburg, Pa.; A. M. Williamson, Niagara Falls, N. Y.; T. Ratray Wilson, Niagara Falls, N. Y.; Wm. S. Weeden, Wilmington, Del.; A. J. Woodworth, Sparrows Point, Md.; W. J. Woolridge, Pittsfield, Mass.; Mr. and Mrs. J. A. Yunck, South Orange, N. J.; Miss Agnes Yunck, South Orange, N. J.; Edward Zaremba, Chicago, Ill.; C. I. Zimmerman, Madison, Wis.; F. Zimmerman, Newark, N. J.

## Notes on Electrochemistry and Metallurgy in Great Britain.

### (*From Our Special Correspondent.*)

### The Faraday Society.

At the meeting on March 30 the paper by Messrs. E. Salersky and E. Adler on "A New Electrical Hardening Furnace" (published in the May issue of this journal, page 203), evolved an animated discussion.

Mr. F. W. Harbord (communicated) said he had used the authors' furnace at the British Westinghouse Company's works for heating a large amount of steel articles at temperatures varying from 800° C. to 1230° C. with most satisfactory results. His purposes demanded not only such temperatures, but also their continuance for considerable periods without variation or oxidation. At over 1200° C. there was no difficulty in confining the variation to 20° C. or 30° C. He enclosed his steel article in a carefully luted iron box to avoid contact with the fused salt, but some bars heated for a long time in contact with the bath gave no evidence of deleterious action. He considered that the entire freedom from oxidation and the ease and regularity of the control of temperature made this furnace exceptionally valuable; and if a furnace could be designed to compete commercially with large heating furnaces great possibilities were in view. Freedom from oxidation was one of the most important modern requirements.

Mr. W. Rosenhain (communicated) was of the opinion that the furnace offered decided advantages for the hardening and tempering of steel tools. Protection from oxidation was a valuable feature, but the choice of salts demanded care. The authors quoted a bath of mixed nitrates of sodium and potassium, and this would be strongly oxidizing. The action of chlorides or fluorides at high temperatures would not be so serious, but the effect on the properties of steel due to exposure to these salts had not yet been ascertained. The rapidity of heating obtainable by electric furnace was sometimes advantages, but very rapid heating of metal of uneven cross-section set up expansion stresses, especially if the steel had already been hardened, and risk of causing cracks might arise from the use of this furnace in some cases. Gradual heating up was in many operations a decided advantage and safeguard. The uniformity of temperature obtained was remarkable, but that was largely a matter of sufficient lagging. This type of furnace opened up the question whether heating to such temperatures as would certainly be injurious where the metal is exposed to an ordinary furnace atmosphere, would still be prejudicial when the metal is submerged in fused salts, and

some recent experiences seemed to indicate that there was a great difference. Experimenters should be cautious. The effects of heat treatment by the two different methods might be found to differ fundamentally.

Mr. C. R. Darling( communicated) thought that the authors' claim of greater speed and more equable distribution of temperature for the furnace appeared fully established, but he was not satisfied with the statement of the cost of working. He quoted figures, charging gas at 3s. 6d. per 1000 cu. ft. and electricty at ½ pence per B.t.u., to show that the respective totals would be £3 8 1 for gas furnaces and £2 18 6 for electricity as representing the average conditions in this country. But in large works where producer gas was available the financial superiority of the electric furnace would completely disappear. In view of the difficulty arising from corrosion of the pyrometer sheaths by fused salts, he advocated the substitution of a radiation or an optical pyrometer at temperatures above 1000° C.

Mr. T. Vaughan Hughes (communicated) was of opinion that in the application of a bath of liquid salts for some steel tools the authors were adopting a course fraught with many practical difficulties. He said this on the authority of statements made to him by manufacturers who had given such furnaces extended practical trials and compared them with recent producer-gas fired equipments. The drawbacks are: too sudden heating of the tools; the absence of any current of gas to sweep away occluded gases; the nuisance produced by the salts used, and the inadequacy of the method of dealing with the large quantity of goods. It seemed that the efficiency of the furnace is low in comparison with others now in daily use. It required 20 kw to maintain a temperature of 850° C., as compared with 3 kw per cubic foot in a carborundum furnace at about 1800° C. He quoted particulars and figures of gas-heated furnaces, all in one block, and contended that the cost of the authors' furnace would be about £288 per annum for current as against £208 for fuel and steam in his own patent furnace, in which large trays containing perhaps 100 articles are heated at one time and at a rate which practical experience has proved to give the best mechanical results, and all sorts of complicated steel articles are heated evenly without distortion and without the aid of any pre-heating furnace, as recommended by the authors.

Mr. W. C. Prebble remarked that if tools and similar articles were raised quickly to the temperature of the bath, distortion was likely to ensue, particularly in the case of complicated tools.

Dr. J. A. Harker agreed with Mr. Rosenhain's objection to the use of nitrates in the bath. His experience was that the sharp points and edges of tools were spoilt my surface oxidation, and he considered that the amount of energy consumed by the furnace was unnecessarily large. He referred to an electric furnace at the National Physical Laboratory in which the consumption of energy had been reduced from 3½ kw to 1½ kw, although the heated space was larger than the authors' No. 1 size. The improvement was due to care taken in the lagging, and he recommended this point to the authors' consideration. On heating up, much more than the normal amount of current would be required, and the method of using an auxiliary carbon electrode seemed to him to introduce difficulties. It was possible to get very uniform temperatures in a furnace without stirring by means of a system of vertical tubes cross-connected.

Dr. C. H. Desch was of opinion that the furnace was well-constructed, quite suitable for hardening steels, and adapted to overcome the difficulty of carrying out this operation, by means of skilled observation with the eyes, for a pyrometer was useless in an ordinary muffle.

Mr. Charles Weiss said that the statement of costs in the appendix seemed to him to unduly penalize gas as compared with electricity. Where only a direct current was available there must be the trouble and cost of transformation.

The chairman remarked that the amount of electrical action likely to occur would be dependent to some extent on the form

of the current wave. Electrolysis might occasionally be advantageous.

Mr. E. A. Adler, in reply, stated that the rate of heating was regulated by the voltage and could be easily controlled. Dr. Harker's statement as to the effects of lagging were very interesting, and he wished to know whether those effects were due to the material or to its thickness. There was no difficulty in starting the bath. The initial voltage was only about 70, and gradually fell to 30. The unequal surface of the auxiliary carbon rod caused sparke which fused the salts locally, and it took only a few minutes to bridge across the bath with a strip of molten salt, and only 15 to 20 minutes to melt the whole. He had used optical pyrometers and found them less suitable than thermocouples, but above 1400° C. the optical instrument might be useful. Mr. Hughes admitted the scientific superiority of the furnace, but did not think such accuracy was necessary for industrial work. With oil-cooled transformers transformation presented no difficulties. Large furnaces would be correspondingly more efficient.

### Corrosion of Steel.

In a paper read before the Society of Chemical Industry Mr. G. Nevill Huntley said that not only the effect of carbon dioxide, but also that of sulphur must be taken into account, as instanced by a stand-by boiler in which large blisters occurred, varying in size up to 30 mm in diameter, the bulk of them being in the neighborhood of the water level. On pricking the blisters each was found to contain a certain liquid with a fine black powder in suspension, and a grit was forming in the center of each blister. The liquid was strongly acid to litmus and consisted of a solution of ferrous sulphate, with a slight excess of sulphuric acid, either free or possibly ferric sulphate. The boiler water was slightly alkaline.

Mr. Huntley summed up by saying that in the periods of rest of the boiler, the oxides deposit on the spot where they are formed, giving a coherent membrane, which admits oxygen and not alkali, which accounts for the acid corrosion going on inside an alkaline water.

The author pointed out that streaks of sulphide in the steel may account for this action, and that sulphur in iron combined as manganese sulphide is not as harmless as formerly supposed. He added that these blisters were entirely stopped by the substitution of an alkaline arsenite for caustic soda in the boiler water.

According to a paper of Mr. Edward Crave (Stockton-on-Tees), there are three principal theories: First, the carbonic-acid theory; second, the peroxide theory ,and, third, the electrolytic theory. There is also a bacterial theory, which is, however, open to question.

Corrosion may take place imperceptibly or with great rapidity and the corrodibility of steel is affected by the presence of alloys. Aluminium, manganese, antimony and arsenic when alloyed with iron or steel are said to increase the liability to corrosion, while nickel, cobalt, tin, copper, chromium and phosphorus decrease this liability.

As the results of some tests carried out by Mr. S. Saniter on ordinary ship steel and steel containing 3½ per cent of nickel dipped continually into sea water, the protection afforded by even this high percentage of nickel is so very slight as to be quite negligible. The amount of copper in commercial steels exerts practically no beneficial influence. Phosphorus, however, is a powerful antidote, but it would appear that no constituent alloyed with iron will give suitable protection against corrosion. The only method, therefore, is to apply a protective covering.

When paint has been applied over the mill bloom on the plates of a ship, in a few months the scale peels off with the paint attached in more or less large patches. If, when the whole of the scale has come off, the ship or structure is thoroughly cleaned of all traces of corrosion and then painted, the protection will, in all probability be permanent, but if any rust is left on the steel, corrosion will continue beneath the skin of paint.

The protective covering of ship plates is, however, liable to damage by rubbing against dock walls. Some waters cause very rapid corrosion of the plates of a ship, and petroleum floating on the water causes the paint near the water line to become soft and slimy and easily detachable. Corrosion takes place more readily at the widest part of the ship, while rivets have been found to be more liable to corrode than the steel plates themselves.

Experience shows that after a ship has been dry docked and properly cleaned and painted there is no further corrosion, and that the identification marks which are put on the plates at the works are always intact, no corrosion taking place upon the surface covered by these marks, which are made with white lead thinned with turpentine and put on while the plate is still hot from the rollls.

The following methods are suggested for protecting steel: (1) Painting while hot and before moisture has penetrated the scale; (2) removal of scale by pickling before painting; (3) exposure without paint until all scale is detached, carefully cleansing and painting; (4) coating the steel work with Portland cement, this latter forming the most perfect covering.

LONDON, May, 1909.

## RECENT METALLURGICAL PATENTS.

### Nickel and Nickel-Steel

**Nickel-Steel From Nickel-Iron Ore.**—The immense deposits of iron pyrites, containing nickel and copper, in Ontario, have formed a very attractive problem for metallurgists for a series of years. They have chiefly been worked for nickel and in the past it has been the practice in producing nickel to throw away the usual large quantity of iron in the ore, as completely as possible with not too great a loss of nickel, the aim being to make as pure a nickel as possible. The nickel-copper matte obtained in the usual treatment is separated by the Orford process (though the electrolytic process of D. H. Browne has also proven successful on a commercial scale). A radically different process has now been devised by Mr. Anson G. Betts, who has already revolutionized lead refining. If his new process turns out a commercial success, it would mean an even greater revolution in nickel-steel manufacture. The fundamental idea of the process of Betts is to roast the sulphide ore into a nickel-iron alloy, containing any copper or precious metal of the ore, and to electrolytically refine the alloy, for the production of purified nickel-iron cathodes, which may then be converted into high-grade nickel-steel by melting with the proper additions. "Nickel-iron alloys can be refined in a similar manner to the electrolytic refining of nickel or iron alone, depositing on the cathodes nickel-iron alloy. Copper, silver, gold, platinum, etc., in the crude alloy remains as an anode slime, from which the valuable metals may be readily recovered." There is a tendency to deposit an alloy with about three parts of iron to one part of nickel, if the solution contains plenty of each metal, and if it is in motion. In view of Mr. Betts' previous success, his new process, the success of which would create a very large new electrolytic industry, deserves careful attention. If the metallurgical and mechanical difficulties which are involved in every new process can be overcome, the process appears to be quite an attractive financial proposition. (923,005, May 25.)

**Treatment of Nickel-Copper Pyrrhotite.**—The same metallurgical problem is the subject of a patent by Mr. F. R. Carpenter, who also endeavors to save the iron by proceeding as follows: The pyrrhotite, carrying copper and nickel is freed from the accompanying gangue, then crushed, and given an oxidizing roast, whereby nickel and iron are oxidized and the copper remains unchanged, while the sulphur passes off as sulphur dioxide. The product of this roast is then treated by the Longmaid-Henderson process, i.e., it is mixed with a proper percentage of common salt and given a chloridizing roast and then the chloridized copper leached, preferably with hot water.

from the remaining ore. If the operation has been properly conducted, at least 95 per cent of the copper and little or no nickel may be extracted with hot water from the residues which are now essentially the purple iron ore, or "blue billy" of commerce, save that these residues will carry practically all the original nickel and little, or no, copper. The small percentage of the original copper which may not be extracted by hot water because in the form of oxides may be recovered by leaching with a weak solution of hydrochloric acid, which may also dissolve a little nickel, but which can be recovered with the dissolved copper. In extreme cases this loss of nickel is found to be small in amount. The principle of the process depends upon the fact that when the three metals—copper as sulfide and nickel and iron as oxides—are given a chloridizing roast, copper is chloridized and nickel and iron remain unchanged, and the copper is thus made soluble in water. "This process is one of such accuracy that not more than one-tenth of 1 per cent sulphur will remain in the residue." After this treatment the nickel-iron residue is smelted directly with or without other iron ores, but with proper fluxes for ferronickel or made into nickel-steel. (922,388, May 18.)

### Steel

**Calcium-Silicon Alloy for Steel Refining.**—In connection with the article of Dr. Hans Goldschmidt in our Vol. VI, page 244, on "calcium silicide for the purification of metals, particularly steel," his recent patent for the preparation of a calcium-silicon alloy is interesting. Two parts, by weight, of lime are mixed with one part, by weight, of silicon and the mixture is heated to about the melting point of cast iron. The lime is in this way partially reduced and the liberated calcium forms with the silicon a calcium-silicon alloy, while the remainder of the lime forms a slag with the silicon. This liquid slag may be regulated so that it crumbles on cooling and thereby enables the easy separation of the calcium-silicon alloy. To aid this crumbling action a flux, such as fluoraspar, is preferably added. If two parts of lime are treated with one part of silicon there results a calcium-silicon alloy which contains about 40 per cent of calcium and is free from carbon. These new alloys are used for aluminothermic purposes and the calcium-silicon alloy is especially useful also for the purpose of refining fused steel. The new alloys are specially adapted for this latter purpose on account of their freedom from carbon, thereby preventing carbon from being newly introduced into the fused steel. Further, the calcium-silicon alloy has the effect of removing the last traces of sulphur which may still be present in the fused steel. The calcium alloy, according to the present invention, has also the action of "killing" the steel and it forms a very fluid slag, which soon mounts to the surface. (921,607, May 11.)

### Welding

**Autogenous Welding of Aluminium.**—In our last two issues we published two articles by Mr. M. U. Schoop on his process of autogenous welding of aluminium plates, wires, sheets, castings, etc., by means of the oxy-acetylene or oxy-hydrogen flame and a special flux. The flux serves no other purpose but to reduce the invisible oxide film always present on the surface of metallic aluminium. This flux, if present, prevents successful welding. But by dissolving this film the flux permits the two parts of aluminium to flow freely together and make a perfect joint. This flux, which is the feature of the whole process, is the object of a recent patent of Mr. Schoop. For use with the oxy-acetylene flame he usese a mixture, by weight, of potassium chloride, 60 parts; sodium chloride, 12 parts; potassium bisulphate, 4 parts; lithium chloride, 20 parts. This mixture is fused in a platinum dish, then crushed in a mortar and sufficient water added to form a thin paste. If a blow-pipe flame of lower temperature than that produced by the oxy-acetylene flame be employed, such, for instance, as that produced by oxygen and illuminating gas, or oxygen and hydrogen, it is desirable to increase the proportion of potassium bisulphate in order to lower the point of fusion of the mixture.

The action of the flux is dual: Firstly, its effect is that of dissolving the aluminium or thin films of aluminium oxide that are formed, and, secondly, it protects the hot metallic surfaces from the air, so that in this respect it plays a part analogous to that of borax in ordinary soldering operations, and what is of importance is that the melting point of the flux is near the melting point of aluminium. In carrying out the process in actual practice, the dissolving substance is applied to the surface to be soldered in the form of a paste or a powder and the surfaces are heated by means of a blow-pipe until they are fused, immediately after which the fusion of the aluminium itself commences, the melting point of the flux being slightly below that of the aluminium. The flux itself does not enter into the joint so that the process is a true autogenous welding process. (922,523, May 25, 1909.)

### Acid-Proof Tanks

**Tank for Metal Refining.**—The construction of a tank for the electrolytic refining of metals, but evidently of wider practical usefulness, is described in a recent patent of Mr. Anson G. Betts. A tank is first made of concrete or cement in the usual manner and the same may be reinforced if desired, particularly for large tanks. After the concrete or cement is well set, the tank is dried and then submerged in a large pot containing melted sulphur, best near the melting point. Great volumes of steam come off as the tank warms up and all air in the pores of the tank is quickly removed thereby. The temperature is then gradually raised for a number of hours, say, 12 hours, for a tank with 4-in. to 6-in. walls, to a maximum temperature of, say, 155° C., or any higher temperature desired. After the evolution of steam at the maximum temperature has practically ceased, the sulphur is slowly cooled to near the melting point again during a number of hours. The reabsorption of the steam remaining in the pores, or its contraction, produces a vacuum into which the sulphur flows, filling the pores at least near the surface, where a filling is most desired. The tank is then taken out, cooled to a little below the melting point of sulphur, and lined with sulphur as follows: The tank is placed flat on its respective sides, ends and bottom and a thin layer of sulphur poured on and allowed to solidify, thereby providing a lining of sulphur. The concrete or cement so treated, but without this lining, resists acids excellently, but the said lining adheres so well and a further protection is afforded so easily that it is preferable to use it. If melted sulphur is plastered onto a concrete surface, which has not been previously specially treated, it soon cracks off. The sulphur lining is itself somewhat porous on account of the contraction that takes place when sulphur solidifies. Furthermore, sulphur is not absolutely insoluble in water and acids, and the continual presence of traces of sulphur in the electrolytes is not desirable, so a coat of suitable paint or varnish or paraffin is applied to the sulphur surface. In case the sulphur lining is omitted the paint, etc., is applied directly to the sides of the tank. Melted paraffin is excellent for this purpose if the solutions to be used in the tank are not heated, and only a small amount of paraffin is required. Before using the tank it should have a lining of boards to protect it from any injury that might be received from pieces of metal dropping or swinging in the tank. This tank is so solid that the great brittleness of sulphur which causes it to break when there is the slightest "give" is no objection to its use. To make a good exterior, non-absorbent finish on the outside, it may be treated in a similar manner or quickly dipped in melted sulphur, when a smooth, hard layer of sulphur is produced on the surface. Such a tank is non-absorbent and practically proof against dilute acids, even hydrofluoric acid. It is stated that porous earthenware vessels may be treated in a similar manner, or brick may be made non-absorbent and acid-proof. For tank construction, the brick may first be saturated with sulphur in a pot and then laid up with a plastic mortar of kaolin, instead of with melted sulphur. (918,649, April 20.)

## ANALYSIS OF CURRENT ELECTROCHEM-ICAL PATENTS.

**Combined Arc and Resistance Furnace.**—For the reduction of elements which at the temperature of reduction are subject to losses by volatilization (for example, silicon), it is important to remove the reduced products as soon as formed from the zone of maximum heat. For this purpose Mr. Frank J. Tone, of the Carborundum Company, employs a combined arc and resistance furnace. The fundamental idea is to cause the products to descend (by gravity) from the reaction zone of the arc along an electrically heated resistance conductor. One terminal of the furnace is formed by an electrode suspended far above. In a hole in the bottom of the furnace is placed a carbon base-block which constitutes the other terminal. On the central part of this base-block rests a resistance conductor, in form of a column of carbon or other conductive refractory material, which is so formed as to give resistance to the passage of the current and therefore heat the product of the furnace as it descends from the zone of reaction. The upper end of this resistance conductor constitutes the lower electrode of the arc, which is maintained between the lower end of the upper electrode and the top of the resistance conductor. The charge fills the furnace and surrounds the upper electrode, so that the arc is completely enclosed in the mass of charge. As reduction progresses, the reduced products descend along the heated resistance conductor into the receiving space in the lower end of the cavity from which they may be tapped. To express it briefly, the lower electrode is intended to serve both as resistor and as electrode for the arc above. (921,183, May 11.)

**Titanium Oxide.**—Magnetic separation, together with partial smelting, is employed in an interesting manner in a process of F. A. J. FitzGerald and P. McN. Bennie for the production of pure titanium oxide from ilmenite ore, which has the approximate formula FeO. TiO$_2$, but is often accompanied by considerable quantities of magnetite as gangue. The ore is crushed, and after a preliminary magnetic separation (in order to remove any magnetite that may accompany the ilmenite) it is mixed with a reducing agent, preferably coke (so that the mixture contains from 7.3 to 10.6 per cent of carbon) and is heated to a temperature sufficiently high to reduce the iron, but not the titanium, to the metallic state. The reduction process, when 7.3 per cent carbon is used, follows the equation

$$FeO . TiO_2 + C = Fe + TiO_2 + CO,$$
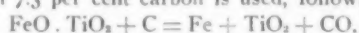
while with 10.6 per cent carbon the following reaction may be expected:

$$2FeO . TiO_2 + 3C = 2Fe + Ti_2O_3 + 3CO.$$

As all that is necessary is to effect reduction of the iron to the metallic state, the percentage of carbon may be such that both reactions occur. The approximate temperature of the reaction is 1800 deg. C. This temperature will give a sintered mass which may more easily be crushed than the compact, fused mass resulting from a higher temperature. By crushing the metallic iron particles are mechanically freed from the titanium oxide. By means of magnetic separation the iron is then separated from the titanium oxide. The non-magnetic portion is then treated with acid in order to remove as completely as possible the small amount of iron not removed by magnetic separation. Digestion with 10 per cent sulphuric acid until no further action takes place is an effective acid treatment. The powder remaining after acid treatment is washed and dried and will be practically pure titanium oxide. (921,686, May 18.)

**Tin Plating.**—The following electrolyte for tin plating is patented by Mr. Jay C. Beneker, the patent being assigned to the Meaker Company, of Chicago: 25 parts sodium hydrate, 15 parts sodium thiosulphate, 10 parts crystallized stannous chloride, 200 parts water. Preferably a solution is made of each, mixing the solution of stannous chloride and sodium hydrate, then adding the sodium thio sulphate. The solution thus formed may be used either hot or cold as an electrolytic bath for plating, but preferably hot. The reaction that takes place is probably as follows: The tin chloride combined with the sodium hydrate forming sodium stannite,

$$2NaOH + SnCl_2 = NaCl + Na_2SnO_2 + H_2O.$$
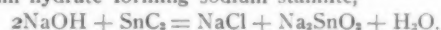
The thio sulphate then transforms this stannite to a sulfosalt changing all or most of the stannous to the stannic form. Probably the chief ingredient in the final solution is sodium thio-stannate Na$_2$SnS. This compound in a high degree can be electrolyzed without the tin separating in a spongy or "tree" form. For tin coatings thio sulphate is employed for the purpose of transforming alkaline or alkaline earth stannites to alkaline or alkaline earth thio stannates, thus changing the valency from the "ous" to the "ic" form, in which form only are the thio salts of tin known. These sulfo compounds are also formed even when the valency is not changed, as in the case where mercuric or stannic salts are made the starting point. With this solution, using any convenient anode but preferably one containing the metal to be plated out, excellent deposits of tin or any allied metal can be plated out without the formation of a spongy or tree-like deposit, even when using high-current densities. (921,943, May 18.)

**Electrolytic Production of Chlorates and Hypochlorites.**—In the production of chlorates and hypochlorites from chlorides by electrolysis, it is important to prevent the chlorate or hypochlorite from being again reduced at the cathode. Mr. A. G. Betts prevents this by employing a cathode of magnesium. In this case there is little or no reduction at the cathode, which is explained by the great superficial oxidizability of the magnesium, so that the surface is always covered with a thin porous layer of non-conductive magnesia, probably in hydrated form, which serves as a thin ever-present diaphragm, preventing the contact of more than small portions of the electrolyte and contained reducible compound with the actual cathode surface. (The hydrogen set free after leaving the cathode has practically no reducing power.) By this method it is not necessary to have any salts of magnesium, calcium, etc., in the solution, so that none of the current is used for the decomposition of such salts. The method is especially useful in the production of hypochlorites for bleaching purposes, having the advantage over the well-known process using an addition of chlorates for the purpose of securing high current efficiency, of producing a colorless solution. In trying to make hypochlorites with a cathode of aluminium, which is almost as oxidizable as magnesium, Mr. Betts found that the caustic generated at the cathode dissolved the aluminium rapidly, and the loss of aluminium was found to be very great in contrast to magnesium, of which the hydroxide is not soluble in caustic solutions. (918,650, April 20.)

**Nickel-Steel from Nickel Ore.**—A. G. Betts has invented an interesting electrolytic process for producing nickel-steel from iron pyrites, containing nickel, copper, etc. The ore is transformed by roasting into a crude nickel-iron alloy, which is used as anodes in a refining bath, the nickel and iron being deposited together on the cathode, while the copper, etc., remains in the anode slime. Details of the process are given elsewhere in this issue, in the department "Recent Metallurgical Patent." (923,005, May 25.)

**Carbon Cell.**—After the carbon cell—that old favorite problem of electrochemists—has had a comparative rest for some ten years, Mr. E. W. Junger, of nickel-iron storage battery fame, has now entered this field. His gas cell for this purpose was described in our Vol. VI, p. 259. In a recent patent he believes he can solve the problem in a more direct way. By using a concentrated sulphuric acid solution, as electrolyte, with amorphous carbon as anode and an unattackable graphite cathode which absorbs oxygen from the atmosphere, he claims he has an oxygen-lift cell in which the electrolyte and the graphite cathode remain unaltered; the whole reaction consists in transportation of the atmospheric oxygen from the cathode to the anode and oxidation of the anodic carbon. To

facilitate this, he adds to the sulphuric acid solution, either gases of nitrogen oxides, like NO, $N_2O_3$, $NO_3$, or chlorine compounds of such gases, or sulphates of manganese, chromium, etc. Two types of cell are described; in one of these a diaphragm is used. The electrolyte is artificially heated. "The working tension of each element at normal charge will, in round numbers, be half a volt. The theoretical tension of the combination carbon-oxygen being about one volt, about 50 per cent. of the energy of the combustion is thus utilized, i. e., about ten times as much as in a modern steam engine." We comment on this cell in an editorial note. (919,022, April 20.)

## SYNOPSIS OF PERIODICAL LITERATURE.

**Ozone for Water Purification and Sewerage Treatment.—** In the London *Electrician* of May 21 an ozone plant for water purification in Nice is described. The power required for the pump is 26 kw, that for the ozonizer is 78 kw. The Otto system is used. The voltage used in the ozonizer is 20,000. In the same article it is suggested that the ozone process could also be applied to the treatment of sewerage effluent. Air is drawn through the ozonizers and is then carried to a mixing chamber which affords thorough contact between the ozone and the water, and the mixture is then carried through a sterilizing gallery, by which means the liquid is thoroughly saturated. "Taking a system in which it is required to treat 25,000 gal. of sewerage effluent per hour, or 600,000 gal. per day, the solids in suspension in the water to be treated may be allowed for at the rate of 3 grains per gallon, or 42.8 grams per 220 gal. The total weight would be 230 lb. per 24 hours. As the matter in suspension would be very fine, it would be necessary to employ a coagulant, such as sulphate of alumina, and to pass the mixture through a precipitation tank, but a roughing tank would usually be sufficient to treat this amount of suspended matter. For pumping purposes a centrifugal pump is employed to raise the effluent to a height of 10 ft at the rate of 31.1 cu. m per second, and taking the efficiency of the pump at 0.6 the necessary power is 6.8 hp. For the production of ozone, allowing 1 gram per 100 gal., 246.4 grams would be necessary for 112 cu. m, and the power would be 7392 watts. Taking into account the efficiency of the alternator this would involve 14.4 hp. The exciter absorbs 0.57 hp, and the total power for the whole plant would be 22 hp. The plant required to deal with this output would be a centrifugal pump, a 15-kw single-phase alternator of 500 cycles, 220 volts, with an exciter, a distributing board complete with instruments for control and measurement, a single-phase transformer converting from 220 to 15,000 volts at 500 cycles requiring about 15 kv-amp, a seven-element battery ozonizer for 246.6 grams of ozone, requiring 1056 watts per element, and an emulser composed of 100 aspirators mounted in a cylindrical iron box with an enameled interior, each having an output of 1.12 cu. m per hour under a pressure of 13 ft."

"For an output of double the capacity the pump power required would be 14 hp, the energy consumption in ozonization 15 kw and the total power for the alternator 44 hp." The author thinks that the scheme is not visionary and gives the following list of other ozone apparatus installed for the purification of drinking water: At Dinard and Cosne 528,000 gal. are treated per 24 hours at each place; at Chartres 1,210,000 gal. per 24 hours; at Armentieres 660,000; at Avranches 506,000; in a second installation for Dinard 506,000, etc., while at the following towns installations have been erected or are in course of construction to deal with 6,000,000 gal. per day: Villefranche, Beaulieu, Saint Jean, Eze, La Turbie, Gabbe-Roquebrune, Mentone, Monaco, Monte Carlo and other towns. Where iron appears very largely in solution it is necessary to precipitate this before using the ozone apparatus, but "it may be roughly taken that for the treatment of 1,000,000 gal. per day of sewerage effluent the cost of the whole of the plant necessary would be

between $15,000 and $20,000, while the working expenses for such a system can be gauged from the figures of power required, given above."

**Iron and Steel Institute Meeting.—**An account of the recent meeting of the Iron and Steel Institute in London is given in London *Engineering* of May 14 and 21. One of the subjects under discussion was the corrosion of iron and steel. Two papers were presented on the theory of corrosion of iron, one by Dr. Wm. H. Walker, the other by Dr. A. S. Cushman, both dealing especially with the electrolytic theory and the possibilities of inhibiting corrosion. A paper by Mr. J. Cruickshank Smith discussed physical tests of protective coatings for iron and steel. As to tests applicable to the paint itself, he discussed the following: The pigment and vehicle should be properly proportioned in order to ensure efficient application and the minimum of free oil space in the dry film; the size of the pigmentary particles should be small and uniform; the pigment and the vehicle should possess the minimum tendency to separate from each other. An accelerative test is possible by exposing the paints to severe conditions for a short space of time, and by examining the films so produced in order to see whether they are free from the defects which one would expect to find in them after so long exposure under milder conditions. Of tests applicable to the film, the following were dealt with: Determination of the thickness and uniformity of the film; strength of film as determined by breaking machine; elasticity of film; permeability of films by vapors and gases; hardness of surface of films.

A very long paper by Prof. E. Heyn and O. Bauer dealt with the influence of the treatment on the solubility of steel in sulphuric acid; a paper by Mr. W. H. Hatfield with the chemical physics involved in the decarbonization of iron-carbon alloys; a paper by Dr. M. Eckenberg with fuel from peat; a paper by Professor McWilliams and Mr. E. J. Barnes on a heat-treatment study of Bessemer steel.

Mr. W. Rodenhauser, of Sarbrücken, Germany, of Roechling-Rodenhauser furnace fame, contributed a paper in which he first summed up what he considered to be the disadvantages of the different arc furnaces, and then described the simple induction and the combination furnace. This paper led to quite a long discussion on the electrometallurgy of steel. Mr. A. Windsor, as a practical steel man, thought the cost of electric steel making would have to be cheapened. The high quality of electric steel was, in his opinion, not so much due to low percentages of phosphorus and sulphur, but to the absence of gases—principally nitrogen and oxygen—in the steel. Mr. O. Frick, himself an inventor of an electric furnace of the induction type, criticised many statements of Mr. Rodenhauser's paper and even defended the different arc furnaces against Rodenhauser's criticisms. He made some interesting remarks on his own furnace, stating that there is now a Frick furnace at work at the Krupp Works at Essen. This is a 10-ton furnace working at an 8½-ton charge, and its results have been so satisfactory that the Krupp firm has taken over his German patent. He stated that the slag could be worked very conveniently in the Frick furnace. Mr. Hiorth, the inventor of another induction furnace, also spoke. Mr. Moorwood urged that the electric furnace should now pass out of the hands of the electricians and be handed over to the steel makers. Mr. A. Cooper thought that the electric-steel furnace could not form a serious competitor until, at all events, it could start with blast-furnace or mixer metal, instead of starting with steel.

The Bessemer gold medal was presented to Mr. A. Pourcel, of Paris, as a recognition of his eminence in the steel industry of France. Mr. Pourcel entered the Terrenoire Works in 1860. He established Bessemer works in 1867; open-hearth steel works followed. He was the first to manufacture ferromanganese and silicospiegel in the blast furnace. He developed the manufacture of solid-steel castings. He built steel works at Bilbao, and an open-hearth plant at the Clarence Iron Works. Sir Hugh Bell will remain president of the Institute for next year.

## Combined Roasting and Smelting Processes for Copper Ores and Fires.

Two novel processes, especially applicable to the treatment of fines, have recently attracted considerable attention. One is the **Fink process,** which has been tried at the Boston Consolidated Company's plant at Garfield, Utah. The other is the **Catton process,** which has been tried at West Seattle, Wash.

Both processes are very similar in principle. In both the furnace consists of two halves, in one of which roasting is carried out, while smelting proceeds in the other, the heat of the gases of reaction in the smelting chamber being directly utilized in the roasting chamber. After roasting is completed, the smelting proceeds in the same chamber, while fresh ore is roasted in the other chamber, so that the function of the two halves of the furnace is now reversed. In this way a high economy of fuel is obtained in both processes. Moreover, both the Fink and Catton processes are designed for use of crude oil as fuel. Finally, in each process fines and concentrates can be roasted without preliminary treatment.



FIG. I.—FINK FURNACE.

Since these processes, if they prove as successful on a large scale as they have proven in the experimental runs, would solve the problem of rendering profitable many propositions at present unprofitable, a brief description of both processes will be interesting.

\* \* \*

In the tests of the **Fink process** at Garfield, Utah, concentrates containing 20 per cent of copper were reduced to blistered copper in a short time. Fig. 1, which is reproduced from the Salt Lake *Mining Review,* shows the two revolving cylinders side by side which make up the Fink smelter. The two ends of the cylinders, which join together at the center, are connected to a central flue. The other two ends of the cylinders are connected to chimneys. In the Garfield plant, with an estimated daily capacity of 100 tons, these cylinders have a length of 9 ft. and a diameter of 9 ft. outside and 7 ft. inside, but tapering at the ends. Near the center of the cylinders there are three tapholes for the removal of slag, matte and metal.

It was intended to use oil as fuel, but since a sufficient supply was not available at the time of the tests, powdered coal was used. The Fink furnace may be compared with a revolving roasting furnace, but differs from the latter in so far as there is no firebox, the fuel being burned in the cylinder itself. The fuel is introduced into the cylinder at the center, where tuyeres are also provided to blow air into the cylinder for bessemerizing.

Both cylinders are in operation at the same time. Let us assume that the roasting operation in cylinder No. 1 has just been completed and that the smelting or bessemerizing in cylinder No. 2 has also been completed. The matte or blister copper is now removed from cylinder 2, but the slag is left in, and a new supply of ore is introduced into 2. Smelting now begins in cylinder 1 and the gases from this cylinder are passed consecutively through the middle flue into cylinder 2 with the fresh ore, which is now being roasted, then into a dust chamber and then to the stack. No fuel is required for the roasting in cylinder 2, the sulphur from the ore and the hot gases from cylinder 1 being sufficient.

At the proper moment the matte or metal is removed from cylinder 1, new fines are introduced into 1 to be roasted, while the roasted ore of cylinder 2 is now smelted, and so on. For bessemerizing, of course, the tuyeres in the center are turned on. The ore, while remaining in the same compartment, is therefore successively roasted, smelted and bessemerized, and no fuel is needed for the roasting operation.

Besides this economy of fuel and the smelting of fines and concentrates without preliminary treatment, other advantages claimed for this process are that the fine ore is not subjected to the blast, but run into the converter slag from the proceeding bessemerizing operation, thus preventing a loss of fines; that the ore is completely converted into metal without preliminary treatment in one compartment, and that the furnace may be used either continuously or intermittently as desired.

According to the newspaper reports the Garfield tests of the Fink process were quite successful.

\* \* \*

Similar satisfactory results are reported concerning the working of the Catton furnace, which is shown diagramatically in Figs. 2 and 3.

The furnace, which is built of brick, is 35 ft. overall long, 10 ft. wide and about 8 ft. above ground. The flues $A'$ and $A$ are continued out to the neck of the stack. A butterfly damper is placed at $B$, while $C$ is a steam pipe in the funnel $D$. Steam is turned on at 90-lb. pressure and syphons air with it through the funnel $D$ and travels through the flue $A$ and on up through the red-hot checker-work chamber and ports $E$, meeting the oil, which is put in under 90-lb. pressure, at $F$.

Combustion immediately takes place and the flame is thrown against the foot wall at $G$ and plunges down in the hearth $H$,
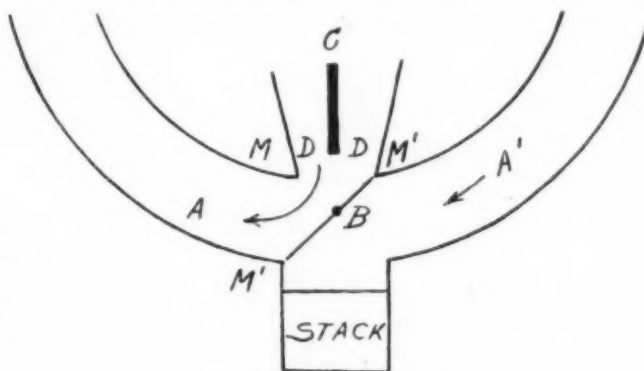


FIG. 2.—CATTON FURNACE.

along which it travels over the well and up the opposite hearth to $H'$, where the first change of ore has been put through the hopper $K$; the hot gases continue on through the port $E'$, the checker-work chamber (keeping it at the required heat) and flue $A'$ to the stack.

When the ore at $H'$ has been sufficiently roasted (the time being from 15 to 45 minutes according to the nature of the ore) the oil is turned off at $F$ and is turned on on the other side, so as to direct the flame now onto the other hearth $H'$. The butterfly damper $B$ is turned from $M'$ to $M$, making the steam and air pass through the flue $A'$ instead of $A$, as formerly, a charge of fresh ore is made at $H$. The oil flame is now turned onto the roasted ore on $H'$, while the hot gases pass over and roast the new charge on $H$. When the first charge at $H'$ has melted it runs down to the well, since the two hearths are built sloping from their extreme ends toward the well in the center. The slag is tapped from the well at $L$ and the matte at $N$. The

whole operation, which takes about one hour, is extremely simple and the heat is under perfect control. The operation begins now all over again; a new charge is being fed into the furnace alternately at either end, and the smelting process is continuous.

The fuel used is crude oil, air and steam. In the tests made matte has been produced assaying from 15 to 42 per cent copper, being concentration of from 6 to 20 to 1, according to the character of the ore, without any preliminary roasting or crushing.
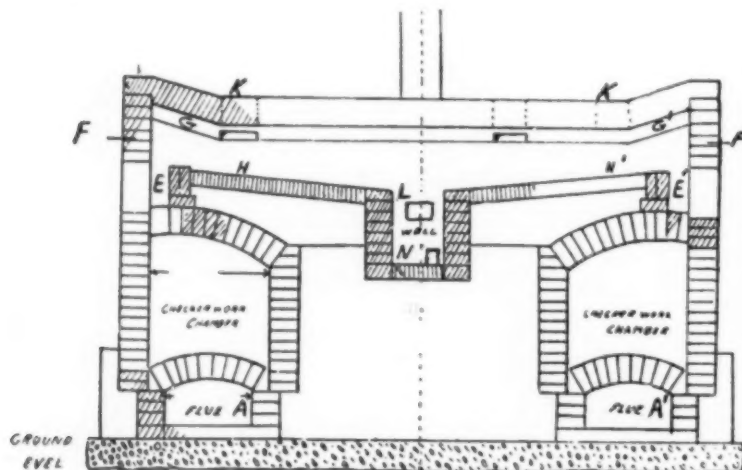


FIG. 3.—CATTON FURNACE.

The Catton furnace is built entirely of brick, common brick wall, firebrick lining and magnesite or chrome brick smelting hearths. It is the use of the oxidizing flame in desulphurizing the ore at one end while the reducing flame is smelting at the other end, which results in the high economy of the process.

At the recent public demonstration of West Seattle it is stated that nothing but mine run of crude ore had been fed into the furnace. With crude ore a concentration of 12 into 1 was made on a charge, carrying 10 per cent sulphur, 5½ into 1 on a 20 per cent sulphur charge, and 4 into 1 on a 28 per cent sulphur charge.

The Catton process of smelting is owned by the State Mining & Smelting Company, of Seattle, Wash., from whom the patent rights for California, Oregon, Nevada, Arizona and New Mexico have been purchased by Col. C. Christopher Seattle, who has retained Mr. Walter S. Keith as consulting engineer. Commercial smelters will be in operation in California and Washington by September of this year.

According to a statement of Mr. Keith the following points have been proven in tests of the Catton furnace during the past six months:

"The cost of fuel per ton of ore smelted will not exceed 35 per cent of blast-furnace cost. The separation made is at least equal to that made in any blast or reverberatory furnace. It can without danger of freezing, maintain a charge resulting in a 50 per cent silica slag. The concentration obtained is equal to that obtained in blast-furnace practice. No flue dust is made during the smelting operation. The loss by volatilization is practically nil."

Mr. Keith estimates that the cost of smelting, in a furnace of 50 tons capacity properly equipped for handling the ores, would not exceed $2 per ton. This, of course, refers to a fluxed ore charge with furnace located on seaboard or main line of railway.

As compared with the Fink process, the Catton process is stated not to require any preliminary crushing whatever, as the ordinary mine run of crude ore can be directly charged into the furnace. With respect to construction, the fact that the Catton furnace is entirely built of brick is considered to represent a great advantage, especially in localities remote from easy shipping facilities. For the first cost it is of importance that no machinery for preliminary crushing is required.

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## Creosote and Zinc Chloride for Wood Preservation.

More than 56,000,000 gal. of creosote and nearly 19,000,000 lb. of zinc chloride were used in preserving timber in the United States last year. Small quantities of crude oil, corrosive sublimate and other chemicals were also used.

These figures are based upon reports to the United States Forest Service of 44 firms which operated 64 timber-treating plants. Assuming that on an average 1 gal. of creosote, or one-third of a pound of zinc chloride, will protect a cubic foot of timber from decay, more than 100,000,000 cu. ft. of cross-ties, piling, poles, mine and other timbers were given a treatment that will greatly increase their life and usefulness.

In 1908 almost seven-tenths—to be exact, 69 per cent—of the creosote used by the treating plants was imported, and but 31 per cent was obtained from domestic sources. Nearly three-fourths of the imported creosote comes from England and Germany, some is obtained in Nova Scotia and some in Scotland and Holland. The domestic creosote used by the treating plants was obtained chiefly in New York, Philadelphia and other large cities.

Creosote is distilled from coal-tar. Not more than 20 per cent of the coke used in the United States is made in by-product ovens.

Were all the tar produced which the coal annually coked in the United States is capable of yielding, it would distill as much creosote as is now used by the wood preservers. Unfortunately, American operators do not even get the fullest use of the limited quantity of coal-tar made in this country for it does not pay the operators to distill coal-tar for creosote alone; so, unless they can find a market for the associated products, it is not separated. Germany has gone far ahead of the United States in the development of coal-tar products, and her exports of them to this country are steadily increasing.

The zinc chloride used in wood preservation is all obtained from domestic sources, according to the reports. Most of it is produced by a few large chemical companies.

Cross-ties are particularly liable to decay, since they are used under conditions which are favorable to the growth of the wood-destroying fungi. Consequently, the railroads have always taken a leading part in timber preservation in the United States. Twelve of the 44 firms which are operating timber-treating plants are railroad companies. The railroads also have many ties treated by commercial timber-treating plants.

In 1907, according to Forest Products Bulletin No. 8 of the Bureau of the Census, the steam railroads of the United States used 19,192,000 treated ties, of which 11,217,000 ties were treated at their own plants and 7,975,000 ties were treated at other plants.

The electric roads used 664,000 treated ties in the same year, nearly two-thirds of which were purchased already treated. The majority of the treated ties used by the steam railroads was preserved with zinc chloride, while with the electric roads more ties were treated with creosote than with any other one preservative.

Many telephone and telegraph poles are creosoted, and there is a growing use of treated timber by the most progressive mine operators. In many harbors, the only practical method of protecting piles from the destructive teredo is to creosote them heavily. One of the most recent uses of creosoted wood on an extensive scale is for rectangular wooden-block pavement. New York, Boston, Baltimore, Indianapolis, Chicago and other large cities are using large quantities. Creosoted wooden blocks have been laid in front of the new terminal station building in Washington.

## Automatic Quartz Mill for Gold Ores.

The Vaughn automatic quartz mill, built by the Vaughn Automatic Quartz Mill Machinery Company, Portland, Ore., is intended for the free milling, concentrating and cyaniding of gold ores. It is similar to the Chilian mill in fine grinding and produces high results in amalgamation in the mortar, without the use of amalgamation plates.

The shape of the rolls, which work in corresponding grooves in the dies in the mortar, make the operation self-adjusting, so that uniform results are obtained from the time that the roll shells are put on new until they are worn out. To replace the roll-shells requires but a few minutes.

Where the ore can be ground to a very fine pulp, in connection with a large amount of mercury, the greatest portion of the gold is recovered at the least expense. In milling ore which contains free gold mixed with lead, antimony sulphides or arsenical pyrite, and most of the base elements in combination, it is claimed by the manufacturers that the Vaughn mill will save from 15 to 20 per cent more of the values than other systems now in use, while requiring only one-third the power. The principal reason for this is that the crushing is continuous, while
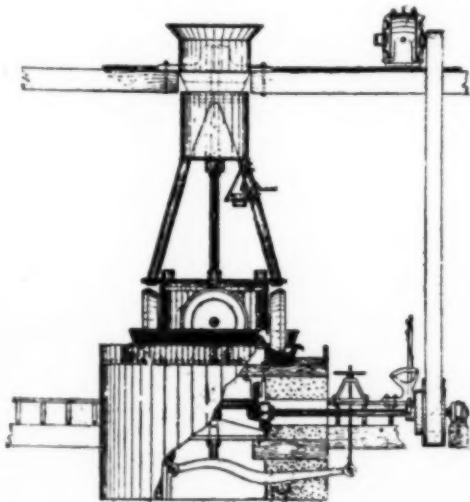


VAUGHN MILL.

with stamps, for instance, but a small percentage of the time is actually consumed in crushing the ore, a great amount of the time being occupied in the lifting and the falling of the stamp. The application of weight, with a rolling pull in a metal surface, with a constant feed ahead of the rolls, is what gives the mill its great capacity, with a small amount of power.

The V-shaped die makes the ore stop at the proper place at all times, and gives positive action for crushing. With this method the ore is uniformly distributed and absolutely under the control of the batteryman.

The Vaughn automatic quartz mill is manufactured in two sizes. The No. 3 mill has a capacity of 25 tons in 12 hours when working on the hardest kind of ore. The power required under the heaviest service is 20 hp; the water required is 15 bbl. to 25 bbl. for free milling and concentrating under heavy service.

The No. 4 mill has a capacity of 50 tons in 12 hours, and requires but little more power than the No. 3 mill, with some more water in proportion to the moisture in the ore.

These mills are interchangeable for wet or dry crushing. The installation of the battery for dry work requires an enclosure of lumber or metal. At the outlet of the pulverized ore an exhaust fan is used to carry the pulp to the cyanide tanks, where it is sprayed with the cyanide solution as it goes into the tanks.

The deterioration of the roll-shells and the dies is usually about 2 lb. of metal to one ton of the hardest rock, in grinding

the ore to 100 mesh to the linear inch. In dry crushing the mill can attain 40 r.p.m. to 50 r.p.m., while for wet work 20 to 25 revolutions is about the maximum speed. When working ore in the dry way all the free gold that occurs in the ore is left in the battery, where it can be cleaned up whenever advisable.

In order to make this clean-up a section of the enclosure is removed and water and mercury is applied in the mortar and
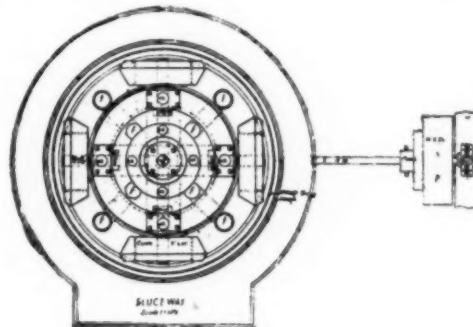


SECTION OF VAUGHN MILL.

the mill put in motion. In a few minutes the gold is all converted into amalgam, which is then ready to be cleaned out.

A building 32 ft. x 32 ft. square is sufficiently large to contain four of the No. 4 batteries for dry work.

Some of the particular advantages of the Vaughn mill, stated by the manufacturers, are that it is possible to take assays at any time while the mill is in operation; that it greatly reduces the usual heavy expense for the mill building (the Vaughn mill being self-contained), and that only half as many attendants are required as with stamp mills.

## A New Viscosimeter.

The new Stormer viscosimeter, designed by Chief Chemist Stormer, of the J. I. Case Threshing Machine Company, and made by the Bausch & Lomb Optical Company, of Rochester,



VISCOSIMETER.

N. Y., is an instrument distinctly new in design. Since it comes from a practical chemist who has found it superior to other forms in making a large number of determinations daily, it may be expected to appeal to other practical men.

The principle employed is that of a paddle wheel driven by a constant force. This paddle wheel is equipped with indicator so that the number of revolutions made in a liquid within a

given time may be recorded, or the time required to register a given number of revolutions may be used as the basis for determining the comparative viscosities of oils, varnishes, etc. The principal points of advantage which have been gained are:

Only 50 cc sample is required for the determination of viscosity and the temperature of this small quantity may be easily controlled.

Only a few seconds are required to make a test and the temperature variation during the test is negligible.

The reading may be repeated and checked with great ease, it being only necessary to wind the indicator back to zero in order to be ready to repeat the determinations.

The force exerted is constant throughout the experiment.

Different oils may be run successively without the loss of time, since a clean cup and a cleaning of the small paddle wheels puts the instrument in order for a new test.

With this viscosimeter there is not such a great variation in viscosities as is shown in some of the outflowing types of instrument.

Only the stop-watch need be kept in mind, since the number of revolutions is automatically recorded and a convenient brake stops the revolution of the wheel instantly at the desired moment.

Further information, direction for use and prices may be obtained of the makers.

## "Permissible" Explosives in Mines.

As a part of the investigation of mine explosions authorized by Congress in May, 1908, it was decided by the Secretary of the Interior that a careful examination should be made of the various explosives used in mining operations, with a view to determining the extent to which the use of such explosives might be responsible for the occurrence of these disasters.

The preliminary investigation showed the necessity of subjecting to rigid tests all explosives intended for use in mines where either gas or dry inflammable dust is present in quantity or under conditions which are indicative of danger.

With this in view, a letter was sent by the director of the United States Geological Survey on Jan. 9, 1909, to the manufacturers of explosives in the United States, setting forth the conditions under which these explosives would be examined and the nature of the tests to which they would be subjected. The first report on these tests has just been issued by the Geological Survey.

The test requirements for explosives were outlined as follows:

The tests are made by the engineers of the United States Explosive Testing Station at Pittsburgh, Pa., in gas and dust gallery No. 1. The charge of explosive to be fired in tests 1, 2 and 3 shall be equal in disruptive power to ½ lb. (227 grams) of 40 per cent nitro-glycerin dynamite in its original wrapper, of the following formula: Nitro-glycerin 40, nitrate of sodium 44, wood pulp 15, calcium carbonate 1.

Each charge shall be fired with an electric fuse of sufficient power to completely detonate or explode the charge, as recommended by the manufacturer. The explosive must be in such condition that the chemical and physical tests do not show any unfavorable results. The explosives in which the charge used is less than 100 grams (0.22 lb.) will be weighed in tinfoil without the original wrapper.

The dust used in tests 2, 3 and 4 will be of the same degree of fineness and taken from one mine with a view to obtaining a dust of uniform purity and inflammability.

Test 1.—Ten shots with the charge as described above, in its original wrapper, shall be fired, each with 1 lb. of clay tamping, at a gallery temperature of 77° Fahr., into a mixture of gas and air containing 8 per cent of methane and ethane. An explosive will pass this test if all 10 shots fail to ignite the mixture.

Test 2.—Ten shots with charge as previously noted, in its original wrapper, shall be fired, each with 1 lb. of clay tamping

at a gallery temperature of 77° Fahr., into a mixture of gas and air containing 4 per cent of methane and ethane and 20 lb. of bituminous coal dust, 18 lb. of which is to be placed on shelves laterally arranged along the first 20 ft. of the gallery, and 2 lb. to be placed near the inlet of the mixing system in such a manner that all or part of it will be suspended in the first division of the gallery. An exposive will pass this test if all 10 shots fail to ignite the mixture.

Test 3.—Ten shots with charge as previously noted, in its original wrapper, shall be fired, each with 1 lb. of clay tamping at a gallery temperature of 77° Fahr., into 40 lb. of bituminous coal dust, 20 lb. of which is to be distributed uniformly on a horse placed in front of the cannon and 20 lb. placed on side shelves in sections 4, 5 and 6. An explosive will pass this test if all 10 shots fail to ignite the mixture.

Test 4.—A limit charge will be determined within 25 grams by firing charges, in their original wrappers, at a gallery temperature of 77° Fahr., into a mixture of gas and air containing 4 per cent of methane and ethane and 20 lb. of bituminous coal dust, to be arranged in the same manner as in test 2. This limit charge is to be repeated five times under the same conditions before being established.

At least 2 lb. of clay tamping are used with slow-burning explosives.

In reply to the circular letter, applications were received from 12 manufacturers for the testing of 29 explosives. Of these the 17 given in the following list have passed all the test requirements set forth, and are termed "permissible explosives."

Subject to the conditions named below, a permissible explosive is defined as an explosive which has passed gas and dust-gallery tests Nos. 1, 2 and 3 as described above, and of which in test No. 4 1½ lb. (680 grams) of the explosive has been fired into the mixture there described without causing an ignition.

PERMISSIBLE EXPLOSIVES TESTED PRIOR TO MAY 15, 1909.

| Brand. | Manufacturer. |
|---|---|
| Etna coal powder A | Etna Powder Co., Chicago, Ill. |
| Etna coal powder B | Etna Powder Co., Chicago, Ill. |
| Carbonite No. 1 | E. I. Du Pont de Nemours Powder Co., Wilmington, Del. |
| Carbonite No. 2 | E. I. Du Pont de Nemours Powder Co., Wilmington, Del. |
| Carbonite No. 3 | E. I. Du Pont de Nemours Powder Co., Wilmington, Del. |
| Carbonite No. 1 L. F. | E. I. Du Pont de Nemours Powder Co., Wilmington, Del. |
| Carbonite No. 2 L. F. | E. I. Du Pont de Nemours Powder Co., Wilmington, Del. |
| Coal special No. 1 | Keystone Powder Co., Emporium, Pa. |
| Coal special No. 2 | Keystone Powder Co., Emporium, Pa. |
| Coalite No. 1 | Potts Powder Co., New York City. |
| Coalite No. 2 D | Potts Powder Co., New York City. |
| Collier dynamite No. 2 | Sinnamahoning Powder Co., Emporium, Pa. |
| Collier dynamite No. 4 | Sinnamahoning Powder Co., Emporium, Pa. |
| Collier dynamite No. 5 | Sinnamahoning Powder Co., Emporium, Pa. |
| Masurite M. L. F. | Masurite Explosive Co., Sharon, Pa. |
| Meteor dynamite | E. I. Du Pont de Nemours Powder Co., Wilmington, Del. |
| Monobel | E. I. Du Pont de Nemours Powder Co., Wilmington, Del. |

Provided:

1. That the explosive is in all respects similar to the sample submitted by the manufacturer for test.

2. That double-strength detonators are used of not less strength than 1-gram charge consisting by weight of 90 parts of mercury fulminate and 10 parts of potassium chlorate (or its equivalent), except for the explosive "Masurite M. L. F.," for which the detonator shall be of not less strength than 1½ grams charge.

3. That the explosive, if in a frozen condition, shall be thoroughly thawed in a safe and suitable manner before use.

4. That the amount used in practice does not exceed 1½ lb. (680 grams) properly tamped.

The above partial list includes the permissible explosives that have passed these tests prior to May 15, 1909.

It may be wise to point out in this connection certain differences between the permissible explosives as a class and the black powders now so generally used in coal mining, as follows:

(a) With equal quantities of each, the flame of the black

powder is more than three times as long and has a duration 3000 to more than 4000 times that of one of the permissible explosives, also the rate of explosion is slower.

(b) The permissible explosives are 1¼ to 1¾ times as strong and are said, if properly used, to do twice the work of black powder in bringing down coal; hence only half the quantity need be used.

(c) With 1 lb. of a permissible explosive, or 2 lb. of black powder, the quantity of noxious gases given off from a shot averages approximately the same, the quantity from the black powder being less than from some of the permissible explosives and slightly greater than from others. The time elapsing after firing before the miner returns to the working face or fires another shot should not be less for permissible explosives than for black powder.

The use of permissible explosives should be considered as supplemental to and not as a substitute for other safety precautions in mines where gas or inflammable coal dust is present under conditions indicative of danger. As stated above, they should be used with strong detonators, and the charge used in practice should not exceed 1½ lb., and in many cases need not exceed 1 lb.

Inasmuch as no explosive manufactured for use in mining is flameless, and as no such explosive is entirely safe under all the variable mining conditions, the use of the terms "flameless" and "safety" as applied to explosives is likely to be misunderstood, may endanger human life, and should be discouraged.

The report is signed by Joseph A. Holmes, expert in charge technologic branch, and approved by George Otis Smith, as director.

## Filter Press.

In our May issue we described at length the equipment of the Chemical Engineering Department of the University of Wisconsin. The adjoining illustration shows a filter press built especially for this department by Messrs. D. R. Sperry & Company, of Batavia, Ill.

This filter press is made of cast iron; each plate surface has an



FILTER PRESS.

area of ½ sq. ft., and each frame space is equal to 1/24 cu. ft. It can be used for experimental work in various ways. Volatile or oxidizable solutions, which would be affected by contact with air, may be filtered and discharged through an internal channel, away from contact with the air. On the other hand, with ordinary solutions, the filtrate is discharged into an open trough so that the completeness of the filtration may be seen at once. It is also arranged for "absolute washing" or extraction.

As mentioned by Prof. J. C. Dickerman in an article in the *Wisconsin Engineer,* this press is an exact model of a full-sized press of the most modern type, so that data concerning the best pressure, most effective filtering medium, bulk of the compact solid residue, volume of wash liquor or extraction solution necessary, physical and chemical characteristics of the residue or cake, and many other items can be obtained and used with confidence in the design of a plant. The press is available for filtering any substance which will not seriously corrode the iron, such as causticised soda ash, sugar, various salts, etc.

As a means of forcing the turbid solutions into the press a montejus, or pressure tank, has been installed. Either steam or compressed air may be used to exert the necessary pressure. The piping is so arranged that the solution may be heated with steam before filtering. The montejus also serves as a convenient dissolver where heating and agitation under pressure are desirable, and the dilution from the condensed steam can be neglected or allowed for.

## Sulphur in Illuminating Gas.

Gas regulations in force in Massachusetts and elsewhere, calling for gas containing not over 20 grains of sulphur per 100 cu. ft., are a source of great trouble for the gas manufacturer. He must either buy at a premium low-sulphur coal, in which case he has to compete with the iron and steel industry, or he must employ some expensive method of gas purification.

These gas regulations are based on the idea that sulphur in gas is a nuisance and unsanitary. This idea has been repeatedly fought by the gas people; from a recent report by Mr. ATHUR D. LITTLE, chemical expert and engineer, of Boston, Mass., we quote the following results of experiments carried out at Malden, Mass., on the influence of sulphur in gas or air in rooms:

"There is no reason to believe that, under the conditions of their occurrence, sulphur acids formed in burning luminous gas have any deleterious action on wood.

"The use of producer gas with extraordinarily high sulphur contents causes no injury to the cylinders of gas engines.

"The extensive use of sulphur compounds in the tanning industry would have very much greater tendency to cause deterioration of leather than the slight amounts of sulphur gases coming from illuminating gas.

"The concentration of sulphur dioxide along with water vapors on the walls of rooms have some antiseptic value.

"People exposed to sulphur dioxide in high concentrations, as in sulphite paper mills, enjoy usual good health and show no ill effects from such exposure."

\* \* \*

In this connection it will be interesting to review briefly the methods of removing sulphur from gas. The following notes are taken from another report of Mr. ARTHUR D. LITTLE:

In a general way, 60 per cent of the sulphur in coal remains behind in the coke. The great mass of the sulphur leaving the retorts with the gas goes in form of hydrogen sulphide, the percentage of the sulphur in this form being between 80 and 95 per cent of the total. The rest is gaseous sulphur compounds, of which the most important is carbon bisulphide.

The **removal of hydrogen sulphide** by the condensers and scrubbers depends in a large measure upon the way in which these are handled. With the use of fresh water in the scrubbers, but little hydrogen sulphide is taken out; if a strong ammoniacal liquor is used, much carbon dioxide and hydrogen sul-

phide can be removed. The following results were obtained at Springfield, where fresh well water runs into the scrubber and a 10-oz. liquor is obtained at the outlet:

| Inlet | | Outlet | |
|-------|-------|--------|-------|
| Hydrogen Sulphide. | Sulphur Compounds. | Hydrogen Sulphur. | Sulphur Compounds. |
| 660 | 32.7 | 620 | 32.0 |
| 615 | · 34.7 | 580 | 33.6 |
| 730 | 33.2 | 690 | 32.7 |
| 590 | 37.7 | 560 | 37.2 |

When coal gas was first manufactured, it was found that the amounts of hydrogen sulphide which it contained were so great as to render its use impracticable unless this compound could be removed. Its removal in the early days of gas manufacture was effected by the use of lime.

A marked step in advance was made when it was found that this objectionable compound could be removed almost completely by passing the gas through the oxide of iron which reacts with the hydrogen sulphide forming sulphide of iron. When this reaction has proceeded to such an extent that the iron becomes largely converted into sulphide, it must be removed from the purifying boxes and exposed to air.

By this means a second reaction takes place with the regeneration of oxide of iron and the deposit of free sulphur. In this way the oxide can be used over and over again until the percentage of sulphur becomes too high for use in purification. In some cases the oxide, rich in sulphur, is then sold to sulphuric acid manufacturers.

Hydrogen sulphide reacts with lime to form sulphide of lime and some of the more complex lime sulphides. Since, however, the affinity of lime for sulphur is less than for carbon dioxide, the lime sulphur compounds are decomposed by the carbon dioxide of the gas, setting free hydrogen sulphide, which again passes into the gas stream. On this account the action of lime is unreliable.

As the gas enters the lime purifiers the first thing to be absorbed is the carbon dioxide, and consequently near the entering point of the gas the lime is all converted into carbonate. As this reaction proceeds, the lime further and further along the course of the gas is converted into carbonate and the hydrogen sulphide which has previously been absorbed is set free, so that it may happen that gas leaving the lime-purifier box contains considerably more hydrogen sulphides than when it entered.

Changes in the efficiency of the condensers and scrubbers as carbon dioxide removers, or any changes in the retort process whereby more carbon dioxide is formed, will tend to prevent the removal of hydrogen sulphide of lime. So far as the hydrogen sulphide is concerned, it is not an important matter since the oxide purifiers are so much more efficient, and can be relied upon to take care of this compound.

Gas which has been purified by oxide is usually practically free from hydrogen sulphide. That it is absolutely free in a chemical sense is not probable, but the amount is very much less than a grain to 100 cu. ft., and, for all practical purposes, is negligible.

Various tests of purified gases have been proposed. In one of these the stream of gas is made to impinge upon a dry-lead acetate paper during the time in which the reforce sulphur test is in progress, which means for a good many hours. In another method the gas is tested for three minutes with a moistened lead-acetate paper. In either case the formation of a black stain shows the presence of appreciable amounts of hydrogen sulphide, and is usually regarded as condemning the gas.

Hydrogen sulphide in gas is regarded as being more injurious than the other sulphide compounds since it tends to attack brass fittings, etc., with which the unburned gas comes in contact. On combustion, of course, it is no more harmful than any other sulphur constituent of gas since it changes entirely into oxide of sulphur.

**Purification of Gas from Sulphur Compounds other than Hydrogen Sulphide.**—Pure iron oxide has no absorptive capacity for carbon bisulphide or the other so-called sulphur compounds. The oxide may through repeated use accumulate considerable percentages of free sulphur. Free sulphur is soluble in carbon bisulphide, and carbon bisulphide is absorbed by it to some extent. The amount of absorption would probably be influenced by the presence of other gases, and particularly by the temperature. It has been recognized by gas engineers for some time that the oxide containing a fairly high percentage of free sulphur has some value in the removal of sulphur compounds, but the action of the oxide purifiers is not relied upon for this purpose.

Neither oxide nor hyroxide of lime has any absorptive capacity for the sulphur compounds other than hydrogen sulphide. New, clean lime, therefore, when first put into use is of no value for sulphur purification.

When, however, the hydrogen sulphide is absorbed by the lime, with the consequent formation of the calcium sulphides, it shows a marked and somewhat uncertain capacity for the absorption of the sulphur compounds. Just what that reaction is, is not altogether clear, although the most probable view is that the calcium hydroxyhydrosulphide absorbs carbon bisulphide, forming calcium thiocarbonate. It, therefore, follows that for the removal of sulphur compounds it is necessary to have a lime box which is foul from the absorption of hydrogen sulphide. It frequently happens that for no cause which the gas engineer can learn a lime box refuses to perform its function of absorbing sulphur compounds, and the unknown character of the products of reaction have long worked against very accurate scientific control of this process.

The spent lime, which has been converted into carbonate from the carbon dioxide of the gas, has no absorptive capacity for sulphur compounds.

As Mr. Little points out, it is the most universal testimony of gas engineers that one of the most harassing things about gas manufacture is the worry and difficulties incident to the removal of the sulphur compounds. This is an entirely different matter from the ordinary control of purifying boxes, such as oxide purifying boxes, and the reason for the attitude of gas engineers toward the removal of sulphur compounds is due to the unreliability of the whole process as at present conducted.

A number of causes work together to produce this uncertainty. The composition of the sulphur compounds is not well understood. The unpurified gas, as it leaves the retorts, contains variable quantities of these sulphur compounds, and these variations are partly due to obscure causes.

Aside from the fact that carbon dioxide converts the lime into a carbonate which has no absorptive capacity for sulphur compounds, this gas is liable to make sulphur purification uncertain by decomposing the lime sulphides, sending forward into the stream of gas not only the hydrogen sulphide, which would then have to be absorbed by the iron oxide, but also the carbon bisulphide which has been held by the lime-sulphur compounds. Any changes in the processes of firing, condensation or scrubbing, which tend to let through an unusual quantity of carbon dioxide, may upset the whole course of lime purification.

A case in point was the new Beckton works of the Gas Light & Coke Company, of London, for which a very large purifying plant has been installed. But the degree of purification was unsatisfactory, and only after a long investigation it was discovered that the purifying apparatus was ample, but that the condensing and scrubbing system was too small, so that the carbon dioxide was not being removed as thoroughly as it should have been.

The referees showed by analytical work at the various London gas works that the scrubbers were, or should be, fairly efficient removers of the carbon dioxides. On account of the lack of the removal of carbon dioxide at the Beckton works this gas was going forward in unusual amounts and decomposing the

lime sulphides so rapidly that the carbon bisulphide was not being thoroughly removed.

Here was an instance of a case where the very best gas engineering talent in the world was unable for months to diagnose the real cause of the imperfect purification, and illustrates the obscure character of the difficulties which may confront the engineer in the removal of the sulphur compounds.

## Notes.

**Chile Saltpetre.**—According to a recent consular report, the Delegacion Fiscal, or Official Board of Engineers, has reported to the Government of Chile that in their former estimates the amount of available sodium nitrate deposits has been underestimated. "There are undeniably 4,843,000,000 Spanish quintals of sodium nitrate in sight, which by the methods in use at the present time may be produced from the lands measured and estimated in the nitrate region. With an annual exportation of 35,000,000 quintals, which is more than exported in 1907, there is sufficient to satisfy the entire consumption of the world for 130 years."

**The New Copper Process of Mr. Lawson.**—The latest undertaking of Mr. Thomas W. Lawson, of Boston, is the offering of the stock of the Santa Rita (New Mexico) Mining Company and the announcement that a new hydrometallurgical process of Mr. Charles S. Bradley is to be applied. Mr. Bradley's former important work in the field of electrochemistry has been sketched in our Vol. I, page 451. He is probably best known by the Bradley internal heating patent which played such an important part in the aluminium patent litigation, and by the Bradley-Lovejoy process for the fixation of atmospheric nitrogen, which was a commercial failure at Niagara Falls, but, nevertheless, marked the beginning of this new industry which has since (with other processes) proven successful in Norway. It is a pity that Mr. Lawson's big book does not give any further indication of the new Bradley copper process, except the statement that the process is being applied on a practical scale within a gunshot of New York, probably meaning experimental work which is reported as having been performed at the celebrated tin smelter in Bayonne, N. J., which never started operation. Mr. Lawson states, however, that former reports to the effect that this process extracts 100 per cent of the copper of the ore are not true, but that it permits the recovery of "a very large proportion of the copper which remains in any ore after every known process has extracted the copper up to its limit."

**Seventh Annual Congress of Applied Chemistry.**—The congress which is being held from May 27 to June 2, 1909, at London, has attracted a large number of delegates from this country. This is especially pleasing as the present congress will receive an official invitation to meet the next time—in the spring of 1912—in New York City, as has been repeatedly mentioned in these columns. It seems now certain that this invitation will be accepted. From a cable dispatch to the New York Sun we note that Ambassador and Mrs. Reid gave a dinner to the American delegates. A reception followed. Several hundred Americans attended the reception, as well as representatives of various foreign embassies. At one of the first sessions of the section on legislation, Dr. Hugo Schweitzer, of New York, said that inventions should find international recognition. For the benefit of inventors international rules and regulations should be established. He moved that an international committee be appointed to consider and draft proposals for joint international patent and trade-mark legislation with a view to international uniformity, such proposals to be submitted to the international congress of 1912 for discussion and further action. The resolution was carried unanimously and a committee was appointed. Our full report of the proceedings of the congress must, of course, be deferred to our next issue.

## Personal.

Mr. **J. E. Johnson, Jr.,** has resigned as general manager of the Princess Furnace Company, at Glen Wilton, Va. Mr. Johnson has distinguished himself by his early work on the dry-blast process. In a paper read in 1905 before the American Institute of Mining Engineers, he discussed the physical action of the blast furnace and suggested that the chief difficulties in the existing blast furnace could be reduced, if not eliminated, by the oxygen blast.

Mr. **W. A. C. Tape** has resigned as resident manager of the Metallic Alloys Company, of Elkton, Va. (successors to Kendall & Flick). While in this position, Mr. Pape designed, built, and put into successful operation a dry-grinding mill for the treatment of manganese ores, as well as a small smelter for the manufacture of manganese-copper.

Mr. **P. B. Sadtler**, S.B., chemical engineer, formerly of Philadelphia, has been added to the staff of the Swenson Evaporator Company, with offices at 945 Monadnock, Chicago. Mr. Sadtler's experience of several years in evaporating lines, as well as his knowledge of the paper pulp business, manufacture of electrolytic caustic and heavy chemicals and caustic recovery from "black" liquor, mercerizing solutions, etc., will make this company especially strong in these departments. Mr. Sadtler was formerly connected with the West Virginia Pulp & Paper Company and the Geo. M. Newhall Engineering Company.

Mr. **A. H. Reed** has resigned as mine superintendent with the Longdale Iron Company, Longdale, Va., and has accepted a position as mining and mechanical engineer with the Independent Phosphate Company, Columbia, Tenn.

## Obituary.

**C. I. Zimmerman** died in Madison, Wis., on May 15. While on the lake his boat capsized and after being some time in the water he was rescued, but died shortly afterward as the result of the exposure. Mr. Zimmerman was formerly an engineer of the Carborundum Company, of Niagara Falls. During the past year he did post-graduate work at the University of Wisconsin. He has contributed various papers to the American Electrochemical Society, especially on electrolytic condensers. He attended the recent meeting of the society at Niagara Falls, and presented on this occasion an elaborate paper on the physical properties of silicon.

## Digest of U. S. Patents

*Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.*
ELECTRIC FURNACES (*Continued*).

No. 587,343, August 3, 1897, George S. Strong, of New York City.

Arc type, especially designed for the production of calcium carbide. The charge, for example a mixture of lime and carbon, contains sufficient coal-tar or molasses to render it plastic. The plastic mass is forced from hoppers, by pistons, through opposite horizontal cylinders having tapering ends and compression-rolls, into and out from opposite aligned dies, which form the plastic material into electrodes. The arc is sprung between the ends of the ejected portions of the charge, the electric current being supplied to the metal dies. The movement of the pistons and rate of feed of the plastic material is electro-magnetically controlled. A chamber beneath receives the melted product, being provided with an outlet having horizontal gates at different elevations to permit discharge without admission of air. One side of the smelting chamber has a glass door to permit inspection and the introduction of a saw to cut the electrodes apart in case they fuse together. One or more ingredients of the charge to be smelted may be fed downward

directly into the arc from a valved hopper depending into the smelting chamber.

No. 597,945, Jan. 25, 1898, Charles S. Bradley, of Avon, N. Y.

Arc type, especially designed for the production of calcium carbide. The furnace is a wheel, or annular trough, of sheet iron, to which may be attached a series of outer metal sections, the whole forming a circular receptacle 3 ft. in transverse diameter, for a wheel 15 ft. in diameter. The wheel rotates on a horizontal shaft, the series of removable sections being secured to its lower half, constituting the smelting and carbide-cooling chamber, and the upper half of the annular trough being open and empty. A carbon electrode about 4 in. in diameter, and vertically adjustable, depends into the circular smelting chamber at one side of the wheel, and a series of radial copper plugs project from the bottom of the annular trough at regular intervals, these plugs being electrically connected to a commutator on one end of the wheel-shaft, on which bears a brush connected to one pole of the electric generator. In starting the furnace, a body of carbon in placed between the depending carbon electrode and the adjacent copper plug, the wheel is then rotated downward from the carbon electrode, starting an arc, and the mixture of lime and carbon is thereafter continuously fed in, the ingot of calcium carbide subsequently serving as the lower electrode and carrying current to the copper plugs. According to a modification, two depending carbon electrodes may be employed. The wheel makes one rotation in five days. From time to time, a removable half-section is taken off from the trough, at the rear of the wheel, permitting the outer layer of unreduced material to fall away and exposing the solidified core of calcium carbide, pieces of which are periodically broken off.

The electric arc is formed wholly within the mass of pulverized charge, and a wall of unreduced material surrounds the product, air thus being excluded until the product cools. The surrounding layer of unreduced material acts as an effective heat-insulator.

No. 598,318, Feb. 1, 1898, James E. Hewes, Philadelphia, Pa.

Resistance type, especially designed for the production of calcium carbide. The mixture of lime and carbon feeds downward from the bottom of a hopper through a top opening in a horizontal circular iron tube, in which reciprocates an iron rammer. The charge is thereby intermittently fed forward out of the end of the tube and between and in contact with flat carbon electrodes, pivoted to swing horizontally to and from each other. The current employed may be from 1500 amp to 2000 amp, at from 100 to 110 volts. The reciprocation of the rammer and rate of feed is electro-magnetically controlled. The carbide slides down an inclined floor, whereon it cools, and onto a grate through which the unreduced material falls. Both electrodes are completely imbedded in the charge, thereby protected from oxydization by air.

No. 602,815, April 19, 1898, George E. Clark, of Galveston, Tex., assignor to S. Blum, H. Eldridge, D. J. Clark and S. Lazarus.

Arc type, especially designed for the production of calcium carbide, but useful for the production of metal oxides generally. The furnace chamber is a circular pan of iron, mounted to rotate on a vertical central shaft beneath. The pan is lined at its bottom with a plate of carbon, which constitutes one electrode.

The other electrode is a depending carbon rod, the upper end of which is secured by set screws in a metal tube which is vertically adjustable. A feeding plow consisting of a vertical metal plate of about the same depth as the pan surrounds the lower end of the depending electrode and is bent helically inward toward it. This plow carries a protecting hood, depending over the pan. In operation, the plow is lowered and feeds the charge inward toward the arc, being raised to decrease the feed and continuously adjusted until the desired amount of carbide is produced. The upper electrode and plow are then raised and the ingot of carbide removed by crane and tongs.

No. 603,053, April 26, 1898, H. Eldridge, D. J. Clark and S. Blum, of Galveston, Tex.

Arc type. A retort for manufacturing hydrogen gas from water. The retort is a cylindrical cast-iron pot, lined with carbon and hermetically closed at the top by a cover having a stuffing-box. The vessel constitutes one electrode and a vertical carbon rod passing through the stuffing-box constitutes the other. Water is pumped into the pot near the bottom, at one side, by a pipe having a check-valve, is decomposed by the heat and electrolysis into hydrogen and oxygen, the oxygen combines with the carbon of the lining and electrode to produce carbon dioxide, and the mixture of gases escapes through a pipe to a gasometer, having a water seal which absorbs both the major portion of the carbonic-acid gas.

## BOOK REVIEWS.

**Handbuch der Elektrotechnik.** Edited by Prof. C. Heinke. Vol. XI, part II: Wärmetechnik und Signalwesen. By V. Engelhardt, K. Hohage, H. Freytag, H. Schwerin and R. Vogel. 560 pages, 541 illustrations and 26 plates. Leipzig: S. Hirzel.

This monumental German handbook of electric engineering, which is unique in scope and character and will be a credit to the profession when finished, is published in parts, each written by an authority in the field treated. Such a system has both advantages and disadvantages. The information given is authoritative, though it may be occasionally biased on account of the personal relations of the author to the industry. Further, each volume has its own individual character, which is a distinct advantage for that volume, though the whole handbook becomes thereby somewhat unbalanced.

The present Volume XI, Part II, is of a very heterogeneous character. Almost half of the volume is filled by the chapter of V. Engelhardt on electrothermic apparatus and processes. The balance is devoted to chapters on electric blasting in mines by Dr. K. Hohage, on fire-alarm signals by H. Freytag, on electric railway signals by H. Schwerin, and R. Vogel on block signals.

The contents of the last-named chapters indicate a wide-reaching specialization in the arrangement of the handbook. It is to be regretted, therefore, that Mr. Engelhardt's chapter on electrothermics has not been divided into two separate chapters; as it is, it comprises electric heating, cooking and welding processes as well as electric furnaces. Though based on the same principles, the apparatus and methods of both industries are very different.

Mr. Engelhardt is in charge of the electrochemical department of the Siemens & Halske Company and has been intimately connected with the development of the induction furnace. He is, therefore, in a position to write a creditable work on electric furnaces and he has certainly succeeded in doing so. The text is clear and the illustrations are excellent.

The weakest point seems to us the classification employed. It may be correct in theory, but it brings things together in the same chapter which are of a very different character. On the other hand, for instance, Héroult's furnace is to be mentioned both in the resistance furnace chapter and in the arc furnace chapter, as an indication of the fact that such a division of electric furnaces is quite easy on paper, but that it is not always easy to decide whether a particular furnace belongs to one or the other type. As to references to existing literature, it is to be regretted that Engelhardt almost exclusively refers to German books or publications which in many cases do not contain first-hand information.

Although the chapter was up to date when written, it is quite possible that when the whole handbook is finally finished Mr. Engelhardt's chapter will be the first one that will need revision, so rapid is just now the progress of the electric furnace, especially in the steel industry.

The volume is decidedly worth a place in the library of engineers interested in electric furnaces.